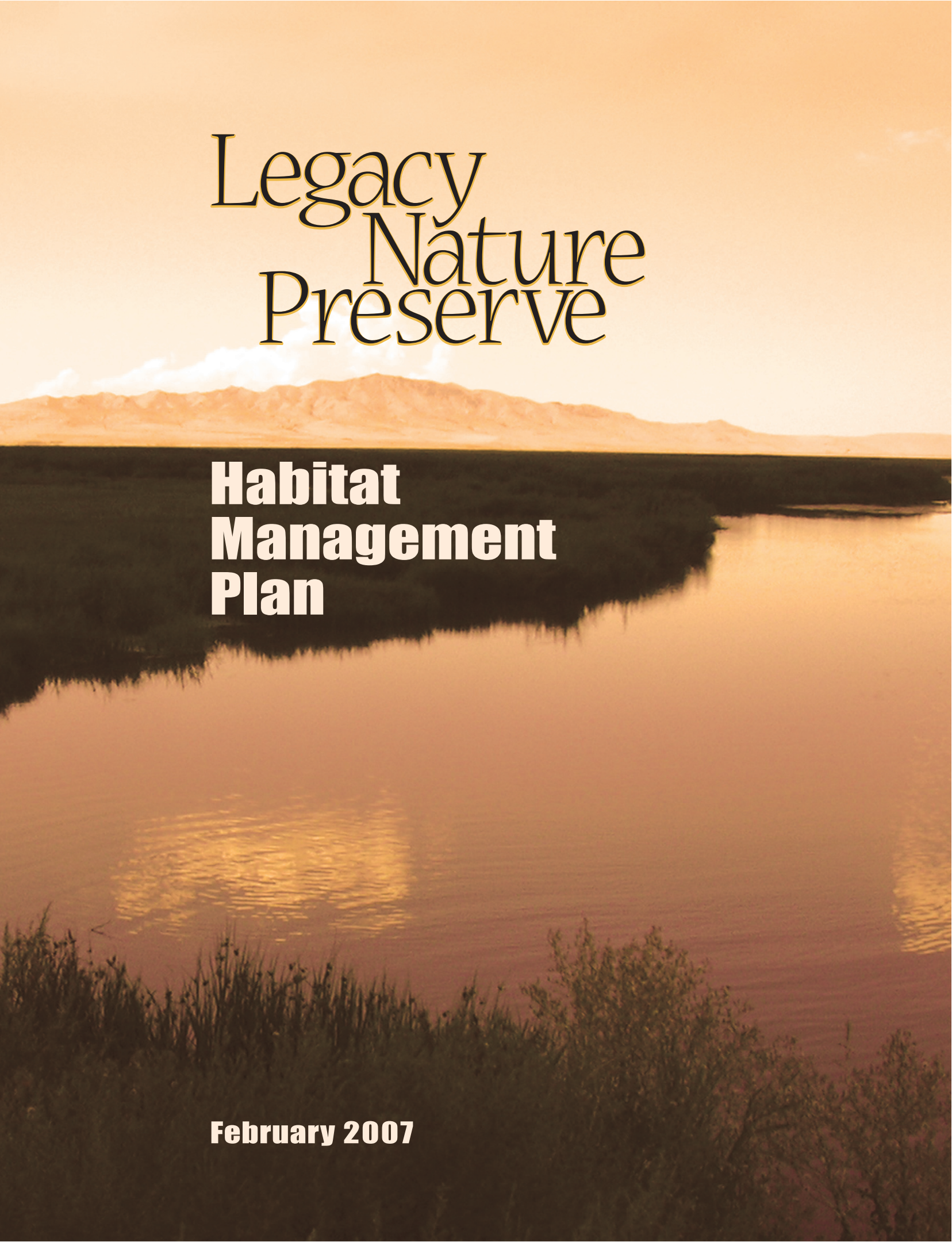

# Legacy Nature Preserve

# Habitat Management Plan

February 2007

# LEGACY NATURE PRESERVE HABITAT MANAGEMENT PLAN

Submitted to

**Utah Department of Transportation**
4001 South 700 East, Suite 450
Salt Lake City, Utah 84107

In Compliance with Section 404 Permit # 200350493

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# CHAPTER 1. INTRODUCTION

## 1.1. SCOPE AND RATIONALE

The Legacy Nature Preserve (LNP) Habitat Management Plan (HMP) is a guidance tool for managing the LNP such that the ecological function of its habitats and related mitigation actions provide quality wildlife habitat particularly (but not exclusively) for shorebirds and other waterbirds. Because the LNP is located in close proximity to the southeastern shore of Great Salt Lake (GSL) and other managed wildlife areas, its contribution as a highly functioning component of the natural resources of the southeastern shore may some day be substantial. There is a real potential for improved wetland and upland habitat through carefully planned and implemented restoration, enhancement, and habitat creation actions. Most of the LNP habitats have been overtaken by introduced and invasive plant species. With appropriate actions and observant monitoring for responses from management prescriptions, desired shifts in plant species composition will gradually become established and habitats for desired wildlife will bring a shift in usage by desired fauna. The premise of the HMP is to focus on resources of concern by identifying priority bird species. Each priority bird species has a group of associate birds as discussed in Chapter 3, whose resource needs will be accommodated if resources for the priority species are managed well.

An inventory and classification of habitat type was developed for the HMP based on soil type, potential for hydrological enhancements, and to some degree, existing vegetation. The topographical footprint throughout the Jordan River floodplain lays the base-plan for what future enhancement may bring; that is, remnant channels and depressions in the floodplain area show very good potential for developing a freshwater marsh area that gradually leads to salt-affected areas that are enhanced by evaporative processes. The upland areas, also formed by hydrogeomorphic processes, provide a mosaic of knolls and alkaline flats that are intermixed with grassland habitat. In these areas, a wide array of wildlife that may or may not use wetland habitat will also benefit from management practices that improve biodiversity and biological integrity of the ecosystem.

By identifying resource needs of the priority species and understanding how each uses specific habitat types (i.e., resting, staging, nesting, foraging, etc.), clear management goals can be outlined and objectives of how to manage the LNP as a highly functioning ecosystem can be described. Additionally, the HMP provides follow up success criteria to help determine appropriate adaptive management decisions that will ultimately render quality wetland and wildlife habitat and bring the LNP into compliance with the conditions outlined in the Clean Water Act, Section 404 permit.

## 1.2. LEGAL MANDATES

Planning efforts for the LNP were initiated in January, 2001 when the original U.S. Army Corps of Engineers (USACE) Section 404 permit was issued for the construction of the Legacy Parkway, mandating the development of the LNP to mitigate for indirect and direct impacts to wetlands and wildlife. During this time, the planning process developed several guidance and binding documents that lay out the construct of why and how the LNP is to be managed, each with a deeper layer of detail.

The overarching, binding document for the LNP is the USACE Section 404 Permit #2000350493, which was released January 20, 2006 specifying that within the 2,098 acres of the LNP, 12 acres of slope wetlands are to be created and wetland functions of 778 acres of existing wetlands within the LNP are to be restored and enhanced. The permit further requires implementation of the Adaptive Management Plan (AMP; SWCA 2005) and revision of the draft Mitigation and Monitoring Plan from Appendix F of the Final Supplemental EIS (Jones and Stokes 2005). The AMP calls for the development of resource management plans including the HMP, which forms the foundation for water management, educational resources and access on the LNP. Although the Section 404 permit states that the revision of the draft Mitigation Plan will include quantitative success criteria, the draft Mitigation Plan (HDR 2006) indicates that success criteria will be developed in the HMP because specific management objectives and related monitoring protocol had not yet been determined. The management objectives and actions provided by the AMP are stated in general terms with the intention that resource management plans (e.g., the HMP) would further flesh out management guidance and prescriptions for each management area (MA) and provide success criteria and monitoring protocol to measure success at the LNP. Hence, the HMP serves two purposes: 1) provides guidance to manage the LNP for quality wildlife habitats for mitigating impacts to wetlands and wildlife associated with the Legacy Parkway; and 2) provides quantitative success criteria by which the success of the LNP can be documented in compliance with the Section 404 permit.

## 1.3. RELATIONSHIPS TO OTHER PLANS

Two other resource plans as called for by the AMP are the Access and Education Management Plan and the Comprehensive Water Management Plan (CWMP). While all resource management plans were developed as stand-alone documents, there are areas of overlapping guidance that command that the plans work in concert with each other. For example, restrictions on access near the Bald Eagle nesting platform during courtship through fledging stages by the U.S. Fish and Wildlife Service (USFWS) affect activities described in all three resource management plans. Also, the addition of water to certain areas of the LNP is critical towards reaching successful mitigation and providing quality habitat, yet it is addressed in two of the management plans from different perspectives. The HMP outlines water requirements that are specific to priority species needs (e.g., depth and duration of flooding), monitoring protocol to ensure habitat requirements are met for each priority species and their associates, and use of water to manage invasive vegetation. Whereas the CWMP outlines a water budget, management of physical structures that enable water movement across areas within the LNP, and monitoring protocol to establish appropriate hydro-periods in surface water systems for priority species throughout the year. The three resource plans each render specific management guidance and collectively provide a vision and purpose for appropriate use of the LNP.

# CHAPTER 2. ECOLOGICAL DESCRIPTION AND CLASSIFICATION OF HABITATS

## 2.1. SETTING

The LNP hosts a wetland system driven by its proximity to GSL consisting of both fresh water and saline environments across the landscape. One of the major tributaries leading to the lake is the Jordan River, which borders the western boundary of the south end of the LNP. During the last 10,000 years, shifts in local faults caused the Jordan River to move relatively fast in a northeastward direction from the southern extent of the lake to its current location. Once in this location a sinuous floodplain developed as water and sediment were transported through the system. In recent history (within the last 100 years), the river has been channelized, its bed degraded, and flows redirected off of its floodplain for water development (agricultural and wildlife management) needs. The floodplain, in turn was left largely unaltered but used for livestock and agricultural purposes. Previous landowners of what is now part of the LNP installed numerous tile drains (currently removed) to lower the water table, making the wetlands more accessible and usable for their livestock. Relict meanders of the Jordan River and its floodplain stretch along the western edge of the southern portion of the LNP in a northward direction at elevations below 4,210 feet, and are the primary area for wetland mitigation and restoration actions for the Legacy Parkway. The footprint of these meanders and depressional areas makes for a continuous and diverse wetland system given the right prescription and application of water.

Upland areas that lie to the east and northeast of the floodplain were also used for livestock and agricultural purposes by former landowners, and have suffered disturbance associated with the former land use (overgrazing, introduced and invasive plant species, loss of topographic features from leveled land). The uplands provide a necessary buffer for wildlife species that use the wetlands and a contiguous corridor that aligns with the floodplain and wetlands to the north. Many upland species will benefit from improved habitat as vegetation control and management efforts are implemented.

### *2.1.1. SOILS*

According to the Natural Resources Conservation Service (NRCS), 13 soil types are found on the LNP. Of these 13, 12 are associated with aquatic moisture regimes and are therefore classified as wetland soils (the only non-wetland soil is found on a very small section in the Farmington Bay MA). All of these soils are influenced by salt and alkalinity to varying degrees. Table 2.1 outlines some specific characteristics of soils found in the LNP.

### *2.1.2. TOPOGRAPHY*

The southernmost section of the LNP is divided into two distinct elevations. The Jordan River (JR) floodplain is situated at roughly 4,208 feet above sea level, which is approximately 8 feet higher in elevation than the average elevation (4,200 feet) of GSL (USGS 2006.) Adjacent to the floodplain is a terrace area, which is 2 feet higher than the floodplain. In many areas, the change in elevations between these two elevations is abrupt (Figure 2.1). The cross sections of the floodplain area generally have a slight bowl-shape, with many internal depressions that collect water. The terrace area also has internal elevation variations. The more northern sections of the

LNP (Farmington Bay and Wet Meadow MAs) range from approximately 4,206 to 4,215 feet in elevation. Much of the Farmington Bay MA has a gradual change in elevation from floodplain to terrace, although the floodplain is associated with GSL bays and not the Jordan River.

**Table 2.1. Locations and Characteristics of Soils Found in the Legacy Nature Preserve (LNP)**

| Soil Name | Location (by MA) | Alkalinity | Range Site Classification |
|---|---|---|---|
| Arave-Saltair complex (AS) | Large areas in the Farmington Bay MA and Alkaline Flats & Slope Wetlands MA. | Strong | Salt meadow |
| Airport silt loam (Ac) | Small areas in the Farmington Bay MA. | Moderate | Alkali bottom |
| Airport silty clay loam (Ad) | Very small area in Farmington Bay MA. | Moderate | Alkali bottom |
| Airport soils, shallow water table (Ae) | Small areas in the Farmington Bay MA. | Moderate | Salt meadow |
| Logan silty clay loam, moderately alkali (Lu) | Entire Evaporative Basins MA. | Moderate | Salt meadow |
| Logan silty clay loam, shallow water table (Lw) | Medium area in the Riverine MA. | Moderate | Wet meadow |
| Payson-Airport silt loams, 0–3% slopes (PMA) | Medium area in the north part of the Farmington Bay MA. | Moderate to strong | Alkali bottom |
| Payson-Warm Springs complex, 0–3% slopes (PNA) | Large areas in the Alkaline Flats & Slope Wetlands, Riverine, and Wet Meadow MAs. | Moderate to strong | Alkali bottom |
| Roshe Springs silt loam, deep over clay (Rt) | Small areas in the Farmington Bay MA. | Moderate | Wet meadow |
| Saltair silty clay loam (Sa) | Small area in the north part of the Farmington Bay MA. | Very strong | Wet meadow |
| Terminal loam (Ta) | Very small area in the Farmington Bay MA. | Mild to strong | Alkali bottom |
| Warm Springs fine sandy loam, 0–1% slopes (WaA) | Small areas in the Alkaline Flats & Slope Wetlands MA. | Mild to very strong | N/A |
| Warm Springs fine sandy loam, deep over clay, 0–1% slopes (WdA) | Small areas in the Alkaline Flats & Slope Wetlands and Wet Meadow MAs. | Mild to very strong | N/A |

Source: Based on NRCS soil survey data, 1968.

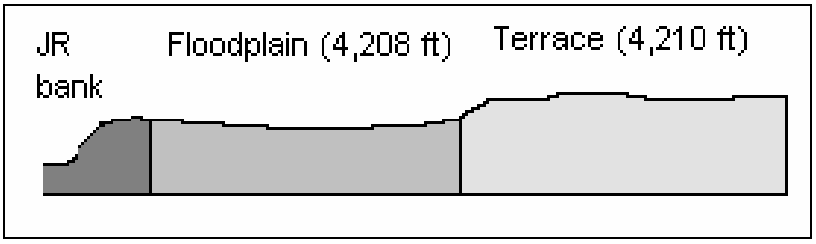


**Figure 2.1. Diagram of the elevation changes between areas in the southern portion of the Legacy Nature Preserve (LNP; not to scale).**

### *2.1.3. CLIMATE*

The climate of western Davis County, Utah is characterized by hot summers (average July maximum temperature of 91.6 °F) and cold winters (average January minimum temperature of 18.6 °F). There are approximately 125 clear days in this part of the state and an average annual precipitation of 23.26 inches. Most of the area's precipitation comes during the spring months—the average precipitation for March, April, and May totals 8.28 inches, which is approximately 36% of the annual total. Winter is the second wettest season, with the months of December, January, and February receiving a total of approximately 6.15 inches of precipitation, or 26% of the annual total, mostly in the form of snowfall. The autumn months receive an average of 5.76 inches, or 25% of the total, and the summer months are the driest, with 3.07 inches (approximately 13% of the total).

## 2.2. SUCCESSION OF UPLANDS AND WETLANDS ASSOCIATED WITH GREAT SALT LAKE (GSL)

Succession of uplands and wetland types within GSL (and Jordan River) floodplain follows a cyclical pattern relative to flooding cycles of the lake. In recent history (mid 1980s) GSL flooded to an average elevation of 4,211 feet but exceeded that elevation to 4,217 feet with wind-driven flows (cf. USGS benchmark at the Ambassador Duck Club). Vast acreage of uplands and wetlands were covered with saline water, which killed practically all the vegetation from lack of tolerance to prolonged inundation and exposure to salt. When lake waters receded, unvegetated areas of higher elevation (upland areas) likely revegetated with weedy forbs (*Chenopodium* spp. and *Atriplex* spp.), followed by salt-tolerant shrubs and grasses like iodine bush (*Allenrolfea occidentalis*), saltbush (*Atriplex* spp.) and saltgrass (*Distichlis spicata*). As salts leached from the surface with precipitation and runoff, other less salt-tolerant species established such as greasewood (*Sarcobatus vermiculatus*), Indian ricegrass (*Achnatherum hymenoides*), basin wildrye (*Leymus cinereus*), and cultivated wheat. Over time, some areas that were barren from exposure to flood waters reestablished vegetation and currently provide habitat for a suite of birds and mammals. Other areas may still be affected by the influence of salt as groundwater levels rise on a seasonal and annual basis.

### *2.2.1. MANAGING FOR SUCCESSIONAL STAGES OF LEGACY NATURE PRESERVE (LNP) WETLANDS*

The LNP is a dynamic area in which the character of the vegetation is closely linked with climate and hydrology. Factors other than lake level fluctuations are also responsible for small-scale changes in soil salinity and vegetation distribution. Changes in amount and duration of precipitation from year to year, as well as alterations to hydrology management, can directly affect soil salinity levels and soil moisture conditions, which in turn affect the distribution and abundance of plant communities. Water table levels are also influential in the changing distribution of plant species, as capillary action from near-surface groundwater creates mineral-rich surface soils that can be too saline for the establishment of most vegetation.

Lacustrine fringe wetlands of GSL follow a cyclical succession pattern relative to flooding episodes of the lake. Salt is probably a more influential factor driving change in wetland type than inundation. However, prolonged inundation, like that of the flood years of the 1980s, in combination with elevated salinity of the water, resulted in more anaerobic conditions in vegetation, wetland types and associated habitat around the lake. Salt is more influential than inundation alone because it remains in the system until gradual dilution processes return what were once relatively fresh water systems back to fresh water. Only certain plants are tolerant of hypersaline conditions, so a limited suite of plant species are the primary settlers of naturally disturbed, lake-influenced conditions. Many wetlands associated with GSL are depressional systems that collect and concentrate salts. Following flood years, those systems retain their salts for some time after other flow-through wetlands (i.e., slope) have reverted to fresher systems.

Within the floodplain, there exists a potential to enhance and restore a variety of wetland types by mimicking flood conditions and adding salt to designated areas with appropriate management of water. Although water management is addressed in depth in the Comprehensive Water Management Plan (CWMP), the overall importance and ecological relevance of water is so pivotal to the successful management of the HMP that it must be addressed in this plan as well. The duration, frequency, depth, and seasonality of flooding play a critical role in the success of managing wetland-related habitats. It is essentially these characteristics, along with salinity, that determine the vegetation community and, thus, the type of wetland or wildlife habitat. Each wetland type provides habitat for various species of wildlife and plants. Each association of wildlife is attracted to specific characteristics of a wetland type that suit their resource needs. For example, migratory American Avocets require open shallow water to forage during the spring, whereas breeding American Avocets require open, sparsely vegetated areas near shallow water to nest during the spring through early summer (see Chapter 3 for other examples).

As water is added to the Riverine MA, salts in surface soils will dilute and leach from surface soils. Surface soils will become saturated in areas of inundation. The depth of inundation will vary with the topography but obligate wetland vegetation will become established by their various tolerances to water depths. For example, root zones of woody species such as willow (*Salix* spp.) that are inundated by groundwater during most of the growing season can establish along the edges and banks of the Jordan River and the North Canyon Meander (see habitat classification map, Figure 2.2). This riparian zone consists of woody shrubs and small trees that are not inundated by water for most of the growing season (i.e., they may be inundated for some portion of the spring during runoff and precipitation events that flood above bank). Some

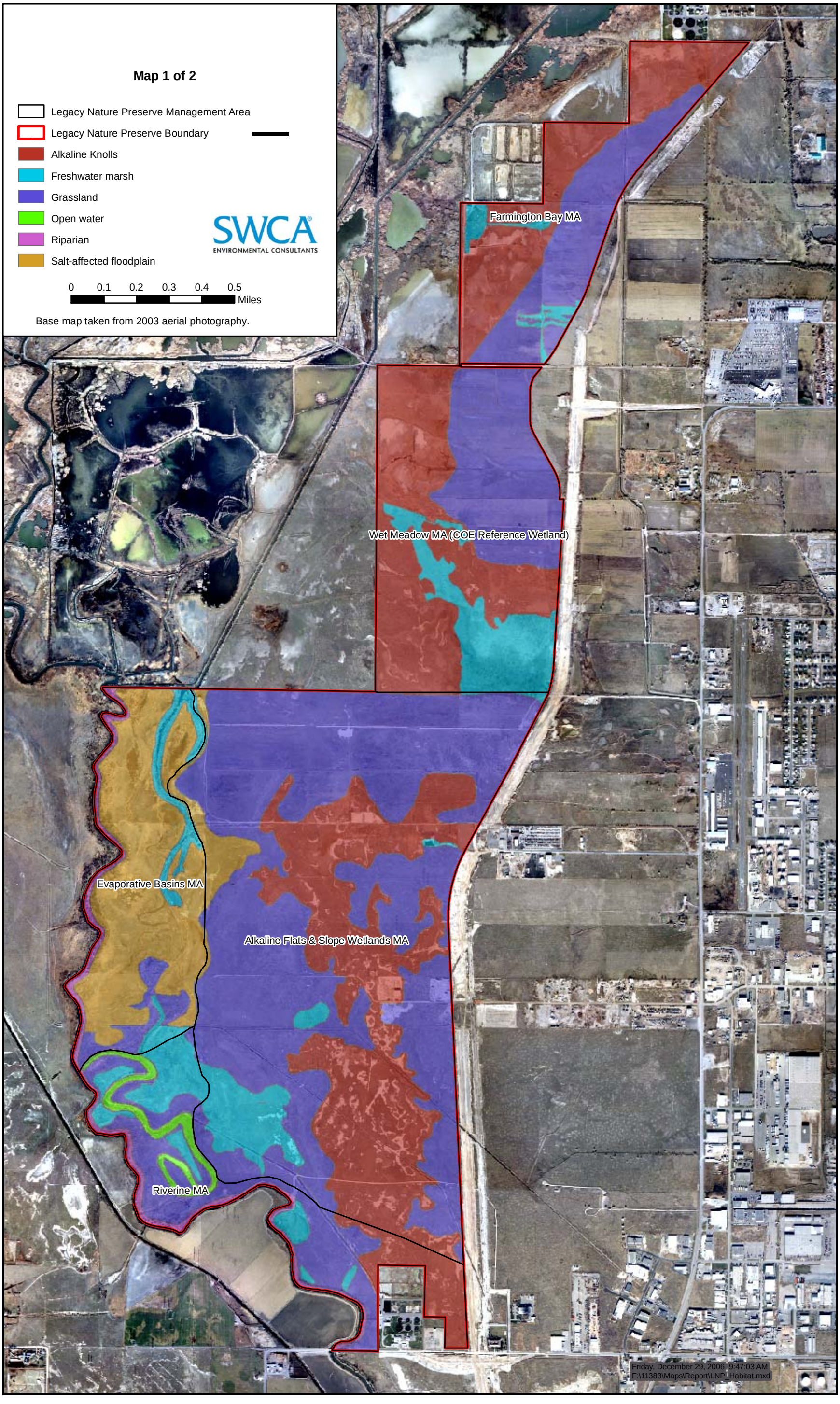


**Figure 2.2. Habitat Classification Map, 1of 2.**

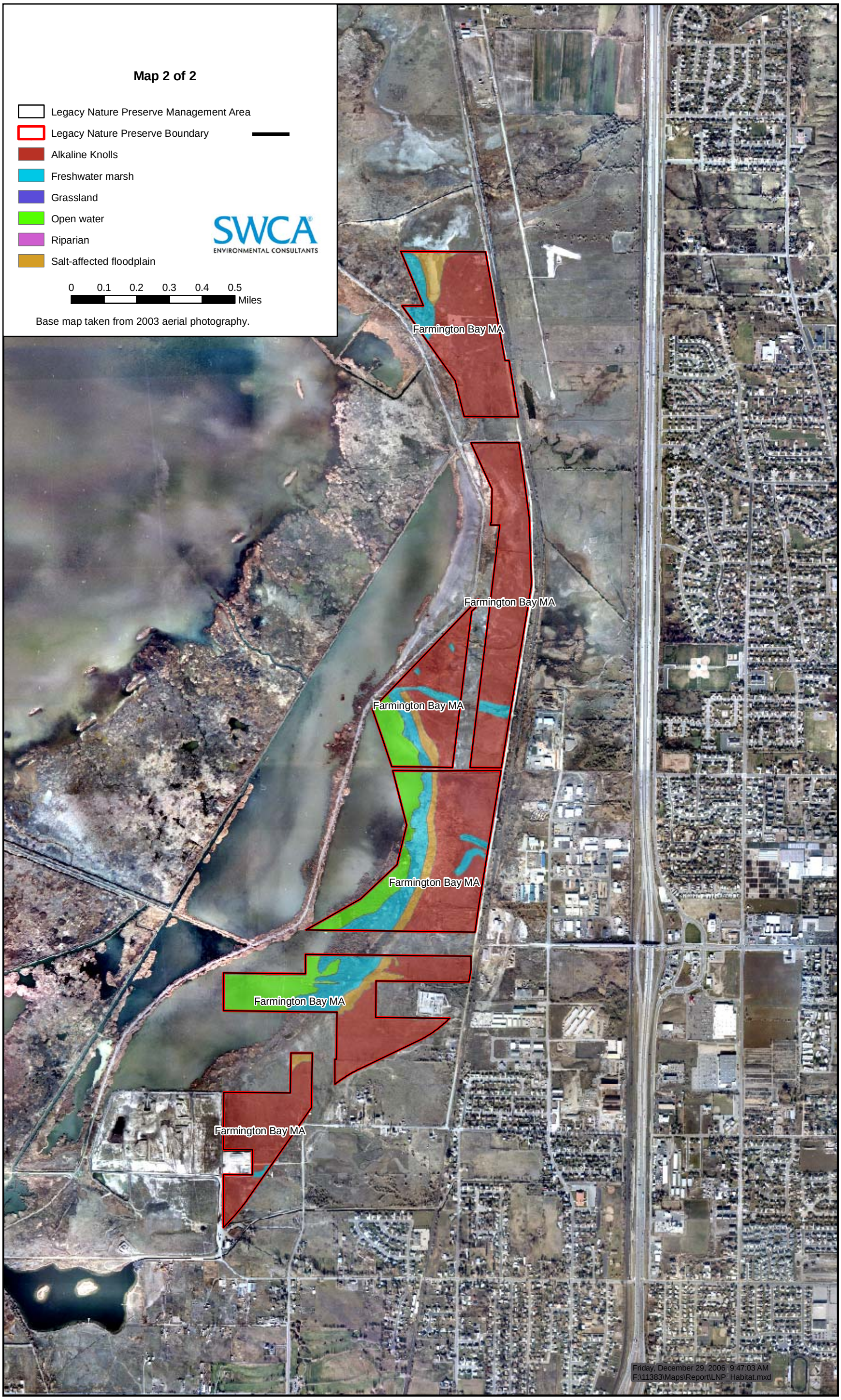


**Figure 2.2. Habitat Classification Map, 2of 2.**

emergent marsh vegetation (described below) may mix with the woody species at the edge of the river and meander waters.

In areas adjacent to the North Canyon Meander that are slightly lower in elevation, such as along the Sorensen Slough, water flows over the meander banks and sheetflows across an area that has topographical depressions. The depth and duration of surface water flow would be expected to limit the establishment of most woody vegetation in these depressional areas if the water source was continuous throughout the growing season. Instead, wet meadow species such as sedges and rushes establish in the shallow areas (approximately 4 inches of water or less), and emergent vegetation establish in deeper, ponded areas. Emergent vegetation can withstand having their roots and basal portions inundated to a depth of 12 inches of water or less, depending upon the species of plant. In some cases, emergent vegetation can grow in slightly deeper water. Emergent vegetation may develop in other areas along the edge of the Jordan River and the North Canyon Meander as well.

Some of the lowest areas adjacent to and east of the Sorensen Slough—remnant saline basins from receding GSL floodwaters—may remain barren, shallowly flooded areas until wet meadow and emergent vegetation types become established. As salts are almost completely removed from the system by managed sheetflow, these basins will become available for vegetation to grow. In the meantime, they will provide good forage for migratory shorebirds, as these areas will likely be productive with macroinvertebrates. Once the basins fill in with sedges and rushes, shifting from an open area to mid-height or taller vegetation, waterbirds may make more use of the changed habitat than shorebirds. More on habitat needs and usage by priority species and their associates are discussed in Chapter 3.

In the Evaporative Basins MA, water will be managed with the goal of concentrating and retaining salts in the system, so that the area becomes open, unvegetated foraging and nesting habitat for various shorebird species. Macroinvertebrates are the primary object of shorebird foraging, and the open basins provide habitat for larval and emerging adult stages. Similar to the Inland Sea Shorebird Reserve (ISSR) "ponds" and the Bear River Migratory Bird Refuge (BRMBR) "alkali bottom," water management in the Evaporative Basins MA will direct water to designated depressional areas (basins) during the early spring prior to nesting windows of shorebirds. Once a certain level of water has collected in the basins, water conveyance to them will cease, and spring and summer precipitation will continue as the only water source.[1] Water in the basins will gradually evaporate with rising seasonal temperatures and recede from the edges of the basins. As the water levels recede, macroinvertebrates in the newly exposed soil and shallow water (less than 6 inches) will provide forage areas for shorebirds.

Since initiation of baseline monitoring in 2001, the six basin areas that lie within the Evaporative Basins MA and were identified for monitoring have become increasingly if not completely vegetated. Basins that were once barren and salty have become overgrown with somewhat salt-tolerant species, such as saltgrass and alkali bulrush (*Schoenoplectus maritimus*) in areas of prolonged inundation, and to a lesser degree, foxtail barley (*Hordeum jubatum*). In other areas of the Evaporative Basins MA that are inundated with water from early winter through the late

[1] This strategy was adopted from water management practices at the ISSR. In the early years of water management at the ISSR, spring precipitation provided enough additional water to cause the ponds to top over and flood active nests. Thereafter, ponds were filled only to 6 inches below the banks in the early spring, to prevent flood damage to active nests. A similar management approach will be applied to the LNP.

spring, salts have been lost from the system and salt inhibited species such as spikerush (*Eleocharis palustris*), and Baltic rush (*Juncus balticus*) have become established. Using water and natural evaporative processes and/or adding salt to selected basins could raise the surface soil salinity levels to prevent vegetation from establishing (other than salt-tolerant pickleweed, *Salicornia* spp.) and restore barren basins to the area.

The topography will need to be carefully assessed to determine the degree of modification that would facilitate direct conveyance or sheetflow to the basins from the Kim's Junction water control structure off the Riverine MA and various locations along the Jordan River. The physical development of water conveyance is addressed by the CWMP. Additionally, the range of soil salinity and other parameters such as nutrient content, pH, and magnesium that sustains a barren or pickleweed-covered basin, maximizes macroinvertebrate productivity, and restricts encroachment of salt sensitive vegetation needs to be identified through assessment of basins that are exhibiting a range of cover conditions (see Chapter 6). However, it may be determined that a basin that was once barren but is now fully vegetated may be left in its current successional stage for educational/research purposes and to provide some diversity in plant community and habitat for wildlife use.

### *2.2.2. Restoring a Natural Succession Process at LNP Uplands*

Based on vegetation soil and hydrology surveys, upland habitat in the LNP has been determined to be of two major types: alkaline knolls and grasslands. Alkaline knolls consist of scattered alkaline flats (wetlands) intermixed with areas of upland vegetation forming the saltbush-greasewood association, and is found mainly in the Alkaline Flats & Slope Wetlands MA and in the Wet Meadow MA to some degree. Grasslands in the LNP were likely a continuation of the alkaline knolls habitat area at one time, until agricultural practices flattened the topography and altered the natural hydrology. Both alkaline knolls and grasslands areas were used for grazing or agriculture until Utah Department of Transportation (UDOT) acquired the land to incorporate into the LNP, at which time these practices ceased. Since then, noxious weeds have invaded most of the uplands, specifically hoary cress and perennial pepperweed. In order to characterize these uplands and restore desirable plant communities and suitable wildlife habitat, it is necessary to understand the natural succession process, how weed species have compromised the system, and where these upland habitats fall on the continuum. It is unrealistic that natural succession will occur in either the grassland or the upland shrub vegetation communities if the only treatment for weeds is removal. This treatment will simply provide an opportunity for other weedy species to invade thereby outcompeting any native vegetation. Therefore, management that attempts to simulate natural succession, e.g., reseeding with early successional native or desirable plants that will be competitive with the invasive plants, maintain soil stability, and provide a seed source is one strategy to manipulate plant communities on the LNP and achieve habitat goals.

The primary succession path in upland ecosystems is from grass-dominant to shrub-dominant communities, although this is dependant on additional factors such as soil chemistry, precipitation, and disturbance regime. However, because of the dynamic lake level that floods and recedes regularly, this successional pathway is subjected to ongoing disturbance that will influence the plant species that can establish in any given year. Grasses will dominate following a flood, and only after many dry years will shrub species appear. Additionally, flooding from GSL results in excess salts shifting new plant establishment to more halophytic early

successional species, such as pickleweed and saltgrass followed by squirreltail (*Elymus elymoides*) and basin wildrye as salts are removed from the system via leaching.

The upland vegetation communities on the LNP generally occur on sites with a seasonal fluctuation in the water table, and are indicative of saline, and often moist soils. Except for flood years, it is typical for this upland habitat to completely dry out by midsummer. This dynamic environment creates challenges when developing a management plan that will mimic natural succession from the currently weed-dominated communities to native plant communities. An adaptive management strategy emphasized throughout the HMP will assist in determining the best implementation processes required to achieve the desired goals in creating functional habitat for the priority bird and wildlife species. Because it is not reasonable to assume a natural successional process will occur, a managed, successional pathway has been developed to mimic a natural, successional pathway for both the grassland and upland shrub habitats.

#### 2.2.2.1. GRASSLAND SUCCESSIONAL STAGE

Management goals for the LNP include providing specific grassland habitat for priority bird species. Grasslands in the LNP are currently more or less a uniform height and could be managed for shortgrass and tallgrass habitats to benefit a more diverse set of birds. Some birds, such as the Long-billed Curlew and Burrowing Owl, require shortgrass habitat, whereas the Grasshopper Sparrow and Cinnamon Teal prefer tallgrass habitat. Seeding with medium to tall grass species and grazing to create shortgrass structure could maintain multiple grassland habitats.

In developing a seed list, grass species were identified that will serve both the shortgrass and tallgrass habitat requirements and could be combined to create a variety of seed mixes. Some of the dominant upland grasses in this ecoregion include squirreltail, purple lovegrass (*Eragrostis pectinacea*), needle-and-thread grass (*Hesperostipa comata*), and basin wildrye. Whereas additional grass species are native and common in grassland communities in this ecoregion, these species were chosen because of their commonality between shortgrass and tallgrass desired species outlined in the habitat types.

Early successional grass species are those that germinate and establish quickly, and the BLM has identified bottlebrush squirreltail as a high priority species for restoration in the Great Basin (Simonin 2001). Because squirreltail is tolerant of disturbance and naturally invades rangelands dominated by cheatgrass and medusahead, it is an excellent species to incorporate into the early successional seed mix (Simonin 2001).

Needle-and-thread grass is a mid-successional species in semi-arid big sagebrush communities (Zlatnik 1999). This species is not competitive against noxious weeds, and should be seeded after weed management techniques have been implemented and a native squirreltail community has established. Needle-and-thread grass is an important component of nesting sites for sharp-tailed grouse in southwestern North Dakota and in Wyoming (Zlatnik 1999), and will be valuable in increasing diversity for other foraging birds and wildlife on the LNP.

Germination of basin wildrye can be low, and may not be useful in early restoration efforts. Priming, a technique by which seeds are partially hydrated to a point where germination processes begin but radicle emergence does not occur, may be used to improve basin wildrye germination (Anderson 2002). This and other perennial grasses outlined in the habitat type

desired plant species will be added after sufficient weed reduction has been achieved, and an established early successional grassland cover has been established.

#### 2.2.2.2. UPLAND SHRUB SUCCESSIONAL STAGE

Upland shrub communities occur in the alkaline knolls and surround depression areas that become inundated with water and form bare evaporative basins ringed with pickleweed. These evaporative basin and pickleweed communities will be maintained by hydrologic modifications as the CWMP is implemented and require no further management at this time.

The upland shrub communities occupy clay-loam, silt-loam, or deep, fine sandy loam soils with high salinity or alkalinity. They are dominated by greasewood, and are associated with big sagebrush *(Artemisia tridentata*), fourwing saltbush (*Atriplex canescens*), rubber rabbitbrush (*Ericameria nauseosus*), and basin wildrye (Donovan et al. 1997). Greasewood is competitive with other plants after disturbance and grows in early seral communities, and is well suited for stabilizing disturbed sites on saline or alkaline soils. This species was chosen as an early successional species because of its ability to establish quickly, and will mimic the natural successional patterns.

The relative abundance of different species may vary in a patchwork pattern across the landscape in relation to subtle differences in soils and reflect variation in disturbance history; total cover rarely exceeds 25% in greasewood-dominated stands (Donovan et al. 1997). The desired greasewood community for the upland habitat types on the LNP also includes low and medium-sized shrubs found widely scattered (1 plant per $m^2$) to high density shrubs (3–4 plants per $m^2$) interspersed with low to medium-height bunchgrasses. Common shrubs should include greasewood, shadscale (*Atriplex confertifolia*), winterfat (*Krasheninnikovia lantana*), fourwing saltbush, sickle saltbush (*Atriplex falcata*), and big sagebrush. Common bunchgrass species include Indian ricegrass (*Achnatherum hymenoides*), needle-and-thread grass (*Hesperostipa comata*), and squirreltail (*Elymus elymoides*), whereas a common rhizomatous/sod forming grass is sand dropseed (*Sporobolus cryptandrus*). Globemallow (*Sphaeralcea coccinea*) is a common and widespread forb. Many of these species are currently present on the LNP and would provide a viable seed source. Transplanting specific shrub and bunchgrass species will increase diversity to obtain the desired upland shrub community. Similar to the grassland communities, the addition of later successional plants in the upland shrub communities will be incorporated following the successful establishment of the faster-growing greasewood.

### *2.2.3. MANAGING FOR SUCCESSIONAL STAGES WITHIN OTHER MANAGEMENT AREAS (MAS)*

The remaining MAs of the LNP have similar wetland and upland habitat types that will cycle through successional stages as related to salinity levels (wetlands) and towards a desired community through active management (uplands). Although there are specific mitigation requirements for the Wet Meadow MA and Alkaline Flats & Slope Wetlands MA, which are covered in detail in the CWMP, these MAs and the Farmington Bay MA will generally be managed for noxious weed control.

## 2.3. HABITAT CLASSES OF THE LNP

The HMP addresses the LNP as a whole and identifies habitat classes and subclasses with respect to soil type, topography, and existing vegetation communities. In this way, the LNP can be treated as a part of the GSL lacustrine fringe wetlands ecosystem. Although the LNP has been subdivided into MAs, this HMP addresses specific management issues, objectives, and goals by habitat type first and *then* applies them within each MA. Reasons for this are to 1) keep the primary focus on improving habitat integrity across the LNP; 2) articulate common management issues that can be addressed within each MA; and 3) avoid making management decisions that are driven by artificial boundaries.

Up to this point, MA boundaries have been used for broad management prescriptions and planning in the LNP. However, it is important to note that MA boundaries are only *loosely* based on ecological conditions at the site, and a variety of habitat types can occur in any of the MAs. Individual habitat types also commonly cross over MA boundaries.

Previous planning documents have not outlined habitat management goals or prescriptions with much specificity because habitat types within each MA had not yet been defined. It is the purpose of this section of the HMP to better characterize the habitat types as they currently exist so that more definitive management prescriptions may be assigned.

The five major habitat types found in the LNP are classified by differences in their hydrology, soils, topography, and vegetation associations. Due to these differences, each habitat type provides a variety of functions for wildlife (Table 2.2). The locations, descriptions, and importance of these habitats and their subclasses are outlined below.

**Table 2.2. Habitat Classes of the LNP**

| | Management Areas | | | | | |
|---|---|---|---|---|---|---|
| **Habitat Type** | **Riverine** | **Evaporative Basins** | **Alkaline Flats & Slope Wetlands** | **Wet Meadow*** | **Farmington Bay** | **Total** |
| Alkaline knolls | 32 | 0 | 269 | 168 | 397 | **866** |
| Grassland | 80 | 19 | 518 | 112 | 90 | **819** |
| Freshwater marsh | 38 | 24 | 43 | 62 | 69 | **236** |
| Salt-affected floodplain | 0 | 166 | 21 | 0 | 25 | **212** |
| Open water | 17 | 0 | 0 | 0 | 50 | **67** |
| Riparian | 19 | 13 | 0 | 0 | 0 | **32** |
| **TOTAL** | **186** | **222** | **851** | **342** | **631** | **2,232** |

* Does not include the 125-acre parcel.

### *2.3.1. ALKALINE KNOLLS HABITAT*

The alkaline knolls habitat type is a major habitat type in the Alkaline Flats & Slope Wetlands MA, the Wet Meadow MA, and the Farmington Bay MA (see Figure 2.2). It is a very diverse habitat type based on vegetation and topography, as it is composed of three subclasses: upland, alkaline flats, and salt meadow. Much of this area is classified as upland and is vegetated with

shrubs such as greasewood and sickle saltbush (*Atriplex falcata*), as well as upland grasses like intermediate wheatgrass (*Thinopyrum intermedium*). Alkaline flats, which are mostly bare ground found in slightly depressional areas, are scattered throughout the alkaline knolls habitat. Bands of wet meadow vegetation, mainly little barley (*Hordeum pusillum*), are commonly found in the transition zones between the upland areas and the flats.

The alkaline flats themselves are distinct from other mudflats in the LNP in terms of soil composition, vegetation, and length of inundation season. Because the alkaline flats are depressional, they collect water in spring when precipitation and runoff are high. The soils throughout the entire Great Basin area are alkaline and sometimes saline, and soil alkalinity levels become concentrated in topographic depressions such as alkaline flats. This occurs mainly because the flats are closed basins having no outflow, which means the only losses of water in this system are through evaporation or seepage into groundwater. When water pools in an area where subsurface soils are alkaline (and saline), its subsequent evaporation draws alkaline salts to the surface soils through capillary action and concentrates them as the water evaporates. These alkaline soils discourage all but the most salt-tolerant species of plants, such as pickleweed (*Salicornia rubra*), Pursh seepweed (*Suaeda calceoliformis*) and iodine bush, all of which are found in the alkaline flats.

The soils in these flats are also strongly influenced by high pH caused by dissolved calcium carbonate ($CaCO_3$). This compound comes from the carbonate rocks, or limestone, that were formed in the Paleozoic era (543–248 million years ago) by coral reefs and shells of marine organisms when much of Utah was covered by the shallow eastern edge of a large ocean (USGS 1993). When calcium carbonate dissociates into the ions $Ca^{+2}$ and $CO_3^{-2}$ in a solution, the $CO_3^{-2}$ ion raises alkalinity by two units. There is more dissolved calcium carbonate in this part of the LNP than in the floodplain area, possibly due to more frequent overbank flood events in the floodplain tending to lower mineral concentrations.

The diversity found in this habitat type is due to the unique geology formed from various erosional processes. Most of the alkaline knolls habitat type is found on a bench that is distinct from the Jordan River floodplain. The upland knolls and surrounding flats were formed as a result of current activity when the area was at the bottom of Lake Bonneville as well as by subsequent differential erosion of materials by eolian processes.

Most of these unique geologic features have been destroyed by agriculture or development since settlers arrived in the area over 150 years ago. The LNP is one of the few remaining places with alkaline knolls that have been mostly untouched, and therefore it is important that these features be protected and enhanced where possible.

The diversity of this area also lends itself to serving in a variety of habitat functions for birds. The alkaline flats are excellent forage areas in the spring when they accumulate shallow water; the wet meadow areas provide resting areas, and the upland zones, with their dense cover, are ideal nesting habitat for certain species. Bird species' use of this area is covered in greater detail in Chapter 3.

### 2.3.2. Grassland Habitat

Grassland habitat (see Figure 2.2) is found primarily in the Alkaline Flats & Slope Wetlands MA, on the same bench as the alkaline knolls habitat. At one time, this habitat type was probably a continuation of the alkaline knolls habitat area, but agricultural practices on the land has

leveled the topography and disturbed the natural hydrologic cycles. This in turn altered the vegetation composition, allowing the area to convert into mostly monotypic stands of intermediate wheatgrass and hoary cress (*Cardaria draba*).

Grasslands are important to a large number of birds and mammals. Grasslands in the West are becoming less common as land is altered or developed, and there has been a significantly negative effect on the number of grassland-dependent bird species in Utah and throughout the country. Managing these areas towards more optimal habitat would be beneficial to birds on a local and national scale.

Grassland habitat was included in the habitat classification of the LNP because of the option for reverting some of this land to shortgrass prairie (all grass species being less than 12 inches tall) in order to benefit nesting curlews and other species (see Chapter 3). Other areas of grassland will be managed for tall grass prairie, where grass species can be 12 inches or taller. Soil characteristics will indicate the site's potential for restoration and inform the selection of grass species.

### *2.3.3. Freshwater Marsh Habitat*

Freshwater marsh habitat, which can be found in every MA in the LNP, is also very diverse in terms of hydrology and vegetation. There are three subclasses found in this habitat type: deepwater, emergent marsh, and wet meadow.

The deepwater habitat subclass is infrequent in the LNP and occurs only when standing water is between 4 and 36 inches for most of the year. Within the deepwater habitat subclass, there are three possible types of vegetation that may occur: submersed, floating attached, and floating unattached. Submersed species, such as sago pondweed (*Stuckenia filiformis*), coon's tail (*Ceratophyllum nodosum*), common bladderwort (*Utricularia macrorhiza*), southern waternymph (*Najas guadalupensis*), and longleaf pondweed (*Potomogeton nodosus*), are rooted in underwater soil but do not reach the water surface. Floating attached species that may occur in similar areas of deep standing water are yellow pond lily (*Nuphar lutea*) and American white waterlily (*Nymphaea odorata*). These may become established if the water management regime calls for water year-round in the North Canyon Meander. Floating unattached species that are also likely to occur in areas of deep standing water are duckweed (*Lemna minor*), and Mexican mosquitofern (*Azolla mexicana*).

Emergent marsh is characterized by erect, rooted, herbaceous aquatic vegetation that remains standing until the next growing season (persistent subclass under Cowardin et al. 1979). Emergent vegetation is typically submerged at the roots by shallow water for most of the year, or its roots are associated with the water table during dry years. Standing water in this habitat is usually 2–24 inches deep during the growing season, which is conducive to a dominance of obligate wetland graminoid species such as hardstem bulrush (*Schoenoplectus acutus*), alkali bulrush (*S. maritimus*), chairmaker's bulrush (*S. americanus*), and softstem bulrush (*S. tabernaemontani*). Phragmites (*Phragmites australis*) and cattail (*Typha latifolia*) are also common in this habitat.

Wet meadows are common on the LNP under previous hydrological conditions (pre-mitigation); however, enhanced hydrology in the Riverine MA, Evaporative Basins MA, and the Wet Meadow MA will eventually increase the overall acreage of this habitat type. Wet meadows develop in areas that are inundated under several inches of water for most of the spring but may

be inundated for the entire growing season if hydrologic conditions allow. Species that tolerate this hydrologic regime are Baltic rush (*Juncus arcticus* var. *littoralis*), common spikegrass (*Eleocharis palustris*), and various species of *Carex*.

Freshwater marshes are used by a number of migratory birds. Areas of taller vegetation, as found in the emergent marsh vegetation class, are important cover areas. Submergent marsh vegetation areas provide forage and resting areas. Wet meadows are also good for cover as well as being good nesting habitat for a variety of species.

### 2.3.4. Salt-affected Floodplain Habitat

This habitat type is found primarily in the Evaporative Basins MA in the floodplain area of the Jordan River, but also occurs to a lesser extent in the Farmington Bay MA (see Figure 2.2). The subclasses that are found in this habitat type are salt meadow and evaporative basins. The salt meadow subclass is characterized by a dominance of saltgrass and other salt-tolerant grass species that are able to withstand periodic inundation. The evaporative basins are depressional areas within the floodplain that accumulate salts. This salt acquisition influences the vegetation composition towards a dominance of pickleweed. Sometimes the salt levels in these basins are high enough to discourage all vegetation, resulting in areas of bare ground.

The salt-affected floodplain is approximately 2–4 feet lower than the benched areas and, therefore, is subject to seasonal flooding as the waters of the Jordan River rise. Because of numerous low areas along the Jordan River levee/bank and the addition of a new berm that runs along the State Canal on the northwest edge of the floodplain, hydrological cycles in this habitat area have been difficult to define. Groundwater may also influence the spring flooding in the area. More studies will be done in the near future to determine the length, season, extent, and sources of inundation.

The evaporative basins are a vegetation subclass found in the salt-affected floodplain that occur in shallow depressional areas that collect water during periods of high precipitation or as floodwaters recede. As the water evaporates, salts are left behind on the surface of the soil. Pickleweed is one of the few plants with a tolerance to concentrated soil salinity, which makes it a dominant species of the evaporative basins. In areas where the salinity is too high even for extreme halophytes like pickleweed, bare ground develops. Many species of shorebirds need these barren areas for foraging, since they are easier to wade in, difficult for predators to access, and good habitat for their food, macroinvertebrates.

Vegetation studies in the area have shown that many once-barren areas have been filling in with pickleweed or saltgrass. This may be indicative of a loss of salts in the soils of this habitat type, which may cycle through saline to slightly saline periods with respect to how frequently GSL floods. In order to provide optimal habitat, it may be necessary to inundate areas of this MA so that salts are concentrated and deposited on the surface during the process of evaporation. An additional aggressive treatment might include adding salt to the soil surface to revert areas back to saline systems and halt the encroachment of non-salt-tolerant vegetation.

### 2.3.5. Riparian Habitat

Riparian habitat occurs along the edges of flowing water and is important to many migratory birds (Stevens et al. 1977) and highly specialized species such as the Southwestern Willow Flycatcher (USFWS 2004) that require these zones for survival. Within the LNP, riparian habitat

is found along the bank of the Jordan River in the Riverine and Evaporative Basins MAs and may develop in some areas along the North Canyon Meander and Sorensen Slough. Although there is a great deal of species variation in this type of habitat, it is characterized largely by emergent vegetation that is rooted in the water zone, such as bulrushes (*Schoenoplectus* spp.), and woody vegetation that occurs slightly higher on the banks with roots exposed to groundwater for most of the growing season, like willows. All of the plants in this type of habitat are able to withstand flooding and are adapted to freshwater conditions. With access to a steady source of water, these plants also produce greater biomass than those in nearby drier areas. This factor along with vegetative structure diversity contributes to a high number of bird species in this habitat type—a greater vegetative surface area is related to greater bird species diversity (Medin and Clary 1990).

Riparian areas are in decline due to stresses related to grazing, water pollution, invasive species, and land development. Existing riparian conditions in the LNP are marginal as there are many weed species adjacent to the Jordan River and there is limited structural diversity relative to the number of species and age class. It is for these reasons that riparian areas within the LNP should be enhanced and protected so that an optimum number of bird species can be supported.

The two vegetation subclasses found in this area are the streambank and the overbank areas. Streambank vegetation areas occur directly within the flow of water, and is commonly the emergent graminoid/willow complex as described above. Overbank areas are farther away from the channel but are still influenced by the high water fluxes during spring runoff. These areas are usually vegetated by wetland grass species such as Sandburg bluegrass (*Poa secunda*) or Baltic rush.

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# CHAPTER 3. RESOURCES OF CONCERN

## 3.1. PRIORITY BIRD SPECIES

The LNP contains numerous high-quality habitats, as well as areas with great potential to serve as premier breeding, nesting, feeding, and resting habitat for a wide array of bird species. While there are many common bird species utilizing habitats on the LNP, some species present at the LNP are less abundant, more unique, and/or less likely to have suitable habitat on neighboring portions of the landscape. As managers and stewards, it is our goal to provide optimal habitat for these less abundant, "priority" species and, in the process, create habitat that is beneficial to many other, more generalist species. The habitat requirements of these priority species provide insight into and guidance of restoration goals and criteria when defining vegetation and water monitoring protocol.

With these ecological and management principles in mind, SWCA and members of the Collaborative Design Team's (CDT's) Habitat Subcommittee developed a priority bird list for the LNP. The focus on priority birds ensures that LNP management efforts will enhance specific habitat components suitable to species on the list (e.g., water depth or vegetation structure), as well as other species of the same guild. However, the list will remain amendable, and species may be added to or dropped from the list depending on ongoing management goals and results. Priority species of other taxa (e.g., mammals, amphibians, and macroinvertebrates) may also be given future consideration, although more baseline data need to be collected on these groups. This heuristic use of the priority species list will facilitate adaptive management on the LNP. In addition, the list will help direct management efforts so that resources are well appropriated and will serve as an indicator of agreement among involved parties regarding LNP management options.

### *3.1.1. METHODS FOR SELECTING PRIORITY SPECIES*

Effective and efficient management of natural resources within the LNP requires knowledge of which species and habitats are most in need of our conservation efforts.

Priority bird species were identified by comparing lists of priority species and habitats published at the federal and state levels and then reviewing priority species lists published by local agencies and neighboring refuges. This was accomplished using the USFWS's Endangered Species List, the Utah Division of Wildlife Resources (UDWR) Sensitive Species List, the Utah Partners in Flight (UPF) Priority Species, and the Bear River Migratory Bird Refuge (BRMBR) Priority Species List. Historical data, when available, were considered, as well as the potential for certain habitat types to be restored within LNP. A priority bird list specific to LNP was then derived by comparing these lists to those bird species recorded during line transect surveys on the LNP. Sensitive bird species with the potential to be attracted to LNP following habitat manipulations were also considered. Special attention was given to shorebirds and wetland specialists and upland birds, as many waterfowl species are already favorably managed at neighboring preserves, which manage for waterfowl hunting during the fall months.

Current and historical bird survey data for LNP are limited to visual transect surveys. As management and research continue on the property, the list of priority species may be updated or changed as new surveys are initiated and new discoveries are made. The first species to be added

to the list and formally included in the text of the HMP will be Sora (*Porzana carolina*) and Yellow Warbler (*Dendroica petechia*). While neither of these birds are found on federal or state conservation lists and have not been observed along the LNP bird monitoring transects, they will provide habitat criteria for creation, enhancement, and monitoring of emergent marsh and riparian zones, respectively.

### *3.1.2. IDENTIFICATION OF HABITAT REQUIREMENTS*

Published literature was reviewed for each candidate priority species to better understand their habitat needs and requirements (Cornell 2006). Table 3.1 identifies the major life cycle activities of each priority species at LNP, as well as status on researched priority species lists. Additionally, ranking factor considerations were evaluated for each priority species, and are summarized in Table 3.2. Major habitat types used by each species, as well as the current and projected acreages of each habitat type at LNP were taken into consideration when ranking priority bird species.

Finally, information regarding habitat use was collected from bird transect surveys and species accounts for each priority species, and is summarized in Table 3.3. Some species may be utilizing more habitats within LNP, and additional data will be added with further study and future transect surveys. The overall habitat use information will help managers at LNP combine work efforts in each habitat and MA. The goal then is to maximize habitat development for multiple priority species while streamlining labor and minimizing management costs. Data relating to the functional use of habitats by priority bird species will be collected beginning in Spring 2007, to better understand which habitats are being utilized for different life cycle activities of priority bird species at LNP. This will aid in making management decisions on a temporal scale.

**Table 3.1. Priority Bird Species at the LNP**

| Rank | Priority Species | Life Cycle Activity | Priority Listing Status[1] |
|---|---|---|---|
| 1 | Bald Eagle | Breeding, Nesting, Winter Roosts | USFWS, UDWR |
| 2 | Black-necked Stilt | Nesting, Migration | UPF, BRMBR |
| 3 | American Avocet | Nesting, Migration | UPF, BRMBR |
| 4 | White-faced Ibis | Nesting | BRMBR |
| 5 | Forster's Tern | Nesting, Migration | LNP unique indicator species |
| 6 | Long-billed Curlew | Nesting | UPF, BRMBR, UDWR |
| 7 | Burrowing Owl | Nesting | UPF |
| 8 | Grasshopper Sparrow | Nesting | UPF, UDWR |
| 9 | Wilson's Phalarope | Migration | BRMBR |
| 10 | Cinnamon Teal | Nesting | BRMBR |
| 11 | Sora[2] | Nesting Habitat | Criteria - Emergent Marsh |
| 12 | Yellow Warbler[2] | Nesting Habitat | Criteria - Riparian |

1. USFWS = U.S. Fish and Wildlife Service, federal endangered and threatened species list. UDWR = Utah Division of Wildlife Resources, sensitive species list (2006). UPF = Utah Partners in Flight (Parish et al. 2002). BRMBR = Bear River Migratory Bird Refuge, habitat management plan (2004).

2. Additional information to be added during adaptive management.

## Table 3.2. Priority Bird Species and Ranking Factors for the LNP

| Rank | Species | Ranking Factors |
|---|---|---|
| 1 | Bald Eagle | LNP supports one of 10 known bald Eagle nests in Utah. (UDWR 2006). |
| 2 | Black-necked Stilt | The Intermountain West supports 79% of migrating birds. LNP has the potential to support a portion of the breeding population. |
| 3 | American Avocet | GSL hosts up to 14% of the continental breeding population and up to 55% of the continental population during migration (Paul and Manning 2002). |
| 4 | White-faced Ibis | GSL hosts the world's largest breeding population (USFWS 1992). |
| 5 | Forster's Tern | LNP hosts a small colony of Forster's Tern in the salt-affected floodplain habitat; wetland preservation recommended for newly discovered breeding colonies (Haug et al. 1993). |
| 6 | Long-billed Curlew | Historic survey data from LNP indicates breeding pairs were present within the past 10 years. |
| 7 | Burrowing Owl | Occasional sightings on LNP in addition to established populations on adjacent properties indicate potential to create habitat for this species of concern. Habitat preference is very similar to Long-billed Curlew. |
| 8 | Grasshopper Sparrow | Common sightings on LNP, two regional listings as a sensitive species. GSL is at the southern edge of an isolated western population of Grasshopper Sparrow. |
| 9 | Wilson's Phalarope | GSL recognized as largest staging area in the world (Jehl 1988). |
| 10 | Cinnamon Teal | Marshes of northern Utah support up to 60% of continental breeding population (Bellrose 1980). |
| 11 | Sora | * |
| 12 | Yellow Warbler | * |

* Additional information to be added during adaptive management.

## Table 3.3. Documented Habitat Use by Priority Bird Species at the LNP

| Priority Species | Habitat Classifications | | | | |
|---|---|---|---|---|---|
| | Alkaline Knolls | Grassland | Salt-affected Floodplain | Freshwater Marsh | Riparian |
| Bald Eagle | - | - | Yes | - | - |
| Black-necked Stilt | Yes | - | - | - | - |
| American Avocet | Yes | - | - | - | - |
| White-faced Ibis | Yes | - | - | Yes | - |
| Forster's Tern | - | - | - | - | - |
| Cinnamon Teal | Yes | Yes | Yes | Yes | Yes |
| Long-billed Curlew | - | - | Yes | - | - |
| Grasshopper Sparrow | - | - | - | - | - |

**Table 3.3. Documented Habitat Use by Priority Bird Species at the LNP**

| Priority Species | Habitat Classifications | | | | |
|---|---|---|---|---|---|
| | Alkaline Knolls | Grassland | Salt-affected Floodplain | Freshwater Marsh | Riparian |
| Burrowing Owl | Yes | - | - | - | - |
| Wilson's Phalarope | - | - | Yes | Yes | - |

Data taken from bird transect survey results, 2004-2006. Note: species may be using other habitat types.

### *3.1.3. WATER AND VEGETATION REQUIREMENTS FOR PRIORITY BIRD SPECIES*

Many of the priority bird species at LNP have specific water depth requirements as a part of their various behaviors and life cycle activities. Additionally, many priority bird species have requirements specific to vegetation height. In some cases, several priority species are served by one particular water depth or vegetation height.

Comparative tables of water depth (Table 3.4) and vegetation heights (Table 3.5) illustrate shared preferences among the 10 priority bird species. This information, combined with LNP habitat types, will help managers recognize which water and grassland types will benefit the most species within each habitat. Knowledge regarding priority species preference for particular water depths will be crucial in the design and management of water control features and new hydrology within LNP habitats. Similarly, understanding species preference for particular grassland features will be crucial in the design and implementation of management actions. The amount of effort and space that is managed for each water and grassland type will hinge greatly on how well priority bird species are served by those habitats.

A comparison of water requirements among priority bird species illustrates the importance of shallow and mid-depth freshwater marsh and riparian habitat. Seven of the ten priority bird species prefer fresh water that is from 0 to 12 inches in depth. Managers and hydrologists at LNP can focus more effort and space on providing a large area of quality freshwater marsh and riparian habitat in order to support all of these species. Establishing and maintaining 0–12-inch water depths within the old Jordan River meanders may accomplish much for these priority bird species (see the CWMP for specifics regarding water flow and control structures in the Riverine MA).

A comparison of vegetation height requirements between priority bird species illustrates that priority bird species at LNP have varying needs in both upland and wetland habitats. No one vegetative type or height suits the needs of more than three priority species in any given habitat type. This confirms the need for a mosaic of different vegetative heights throughout habitats at LNP to benefit as many priority bird species as possible. Little management action should be required to maintain areas of bare ground within the alkaline knolls and salt-affected floodplain habitats to support American Avocet, Long-billed Curlew, Black-necked Stilt, and White-faced Ibis. Bare ground in freshwater marsh habitat may require management to control or eliminate

**Table 3.4. Water Depth and Habitat Preferences of Priority Bird Species at the LNP**

| | Shallow Water (0-6") | Habitat* | Mid-depth Water (6-12") | Habitat* | Deep Water (12"+) | Habitat* |
|---|---|---|---|---|---|---|
| Bald Eagle | | | Feeding | FM, RP | Feeding | RP |
| Black-necked Stilt | Feeding | FM | | | | |
| American Avocet | Feeding | SF | Feeding/Resting | FM | | |
| White-faced Ibis | | | Feeding | FM, SF | Nesting | FM, RP |
| Forster's Tern | Feeding/Nesting | RP, FM | Feeding | FM, RP | | |
| Long-billed Curlew | | | | | | |
| Grasshopper Sparrow | | | | | | |
| Burrowing Owl | | | | | | |
| Wilson's Phalarope | Feeding/Nesting | RP, FM, SF | Feeding | FM, RP | | |
| Cinnamon Teal | Feeding | | Feeding | | | |

Note: Grassland and alkaline knolls habitat types are excluded, as they are not persistently wet habitat types at LNP. Priority bird species with no specific water depth requirements are also excluded.

*FM = Freshwater Marsh; SF = Salt-affected Floodplain; RP = Riparian.

**Table 3.5. Vegetation Height and Habitat Preferences of Priority Bird Species at the LNP**

| | Bare Ground | Habitat* | Short Grass (0–12") | Habitat* | Tall Grass (12"+) | Habitat* |
|---|---|---|---|---|---|---|
| Black-necked Stilt | Nesting/Feeding | FM, SF | | | | |
| American Avocet | Nesting/Feeding | AK, SF | | | | |
| White-faced Ibis | Feeding | FM, SF | Feeding | FM, SF, RP | | |
| Long-billed Curlew | Nesting | AK | Nesting/Feeding | GL, AK, FM | | |
| Grasshopper Sparrow | | | Nesting/Feeding | GL, AK | Nesting/Feeding | GL, AK |
| Burrowing Owl | | | Nesting/Feeding | GL, AK | | |
| Wilson's Phalarope | | | | | Nesting | GL, SF, RP |
| Cinnamon Teal | | | | | Nesting | GL, SF, RP, FM |

Note: Priority bird species with no specific vegetation height requirements are excluded.

*FM = Freshwater Marsh; SF = Salt-affected Floodplain; AK = Alkaline Knolls; RP = Riparian; GL = Grassland.

common reed (*Phragmites australis*). Three priority bird species show preferences for tallgrass vegetation (more than 12 inches). These habitats should also be fairly easy to manage, as tallgrass vegetation already exists in many habitats at LNP. Weed control in these areas will be the one management action of highest priority, to allow the establishment and succession of tallgrass plant species. Four priority bird species show a preference for shortgrass vegetation within various habitat types. Creating and maintaining shortgrass (0–12 inches) vegetation types will likely require the most management action compared to bare ground and tallgrass. Management actions such as grazing or mowing will likely be the most effective method to maintain shortgrass vegetation types. Mowing or grazing livestock will require scheduling so that it does not interfere with the breeding and nesting seasons of priority and other bird species.

### *3.1.4. Other Vegetation Requirements for Priority Bird Species*

In addition to water depths and vegetation height, the success of priority bird species establishment requires the management of other vegetation components such as trees, shrubs, and emergent plants (Table 3.6). Revegetation efforts planned for all areas of the LNP will increase the diversity and occurrence rate of native and naturalized plant species in order to benefit bird species. More specific needs of priority bird species are described under Section 3.2.

**Table 3.6. Priority Bird Species' Potential to Use Other Vegetation Components in the LNP**

| Priority Species | Trees | Shrubs | Emergent Vegetation |
|---|---|---|---|
| Bald Eagle | Roosts, perches. | NA | NA |
| Black-necked Stilt | NA | NA | Nests in cattails, bulrush, sedges. |
| American Avocet | NA | Will occasionally be found near greasewood. | Occasionally found near cattail bulrushes, and sedges. |
| White-faced Ibis | NA | Occasionally feeds near greasewood. | Frequently feeds in shallowly flooded wetlands of emergent plants: sedges, bulrushes, spikerushes, pickleweed, and saltgrass. |
| Forster's Tern | NA | NA | Sometimes nests on mats of floating emergent vegetation species. |
| Long-billed Curlew | Avoids areas with trees. | Avoids areas with high shrub cover. | Avoids areas dense with vegetation. |
| Grasshopper Sparrow | NA | Prefers sparse shrub cover. | NA |
| Burrowing Owl | Avoids tree canopy. | Avoids nesting near shrubs. | NA |
| Wilson's Phalarope | NA | NA | Nests near water in rushes, sedges, and grasses. |
| Cinnamon Teal | NA | Occasionally nests at the base of shrubs. | Nests near water in rushes, sedges, and grasses, or sometimes over water in dense bulrushes or cattails. |

NA = Not applicable.

## 3.2. SUMMARIES OF PRIORITY BIRD SPECIES

The following biological summaries for the priority species detail distribution, ecology, habitat requirements, LNP's contribution to habitat needs, and research and monitoring needs. Additionally, a summary of the general nesting ecology of all common bird species can be found in Appendix A. Nesting Ecology of Breeding Bird Species. Migration data may additionally be summarized and included in a future appendix. This information will be useful to LNP managers as both a field reference, and a tool when making habitat management decisions (Cornell 2006). For ease in reading and to shorten the length of each species summary, the primary literary reference is included, while embedded references have been removed (cf. Cornell 2006).

Additionally, information regarding habitat use, population objectives, and suggestions for future monitoring and research is included for each priority bird species. Future monitoring and research projects will provide new information about the breeding, nesting, staging, and population status of priority bird species and help managers understand and monitor the ongoing status of those species at LNP. New studies will require the design of appropriate protocols for collecting data. Qualified biologists and ecologists, prior to the initiation of any new study at LNP, will review new monitoring protocols.

### *3.2.1. BALD EAGLE (HALIAEETUS LEUCOCEPHALUS)*

#### Associated Species

Other species that may respond similarly to habitat components used by Bald Eagles are Osprey, Red-tailed Hawk, and Peregrine Falcon.

#### Distribution

Breeding range tends mostly towards the northern U.S. (specifically Maine, northern Great Lakes, Montana, Idaho, and coastal portions of Washington and Oregon) and Canada, with splotchy distribution of breeding birds in Florida and the Mississippi River valley. Isolated breeding pairs exist where summer forage and nest sites are available, particularly near water where there are ample sources of fish.

In Utah, there are ten known breeding pairs of Bald Eagles; while eagles typically use dead snags, one of the pairs is currently using an artificial nest platform at LNP. Wintering range covers most of the U.S., though eagles congregate at sites where there is ample food—again, near lakes, waterways, or where winter-kill livestock is plentiful.

#### Ecology

The Bald Eagle is a large bird of prey with broad wings for a flapping-soaring flight and a characteristic white head and white tail in adult birds. The species is an opportunistic forager that eats a variety of mammalian, avian, and reptilian prey, but generally prefers fish over other food types. It often scavenges prey items when available, pirates food from other species when it can, and captures its own prey only as a last resort (Buehler 2000).

Pair formation is poorly researched, but seems to take place either on the breeding grounds, or on wintering grounds shortly before the breeding season. Nest building tends to begin 1–3 months before egg-laying, generally around February, though adults have been seen carrying sticks to repair their nest year-round. Bald Eagles may build onto a deserted nest from another raptor

species. Nests are commonly built in a large conifer or dead snag tree. At LNP, the original nest tree was a cottonwood snag. After the snag fell however, it was replaced with an artificial platform, which the eagles have used consistently. Eggs are generally laid in March or early April, though this varies by latitude. Eagles only have one clutch per season. Incubation of eggs is around 35 days, with the female performing the majority of the incubation (Buehler 2000).

Migration in eagles varies greatly depending on individual age, location of breeding site, severity of weather at the breeding site, and availability of food. Immature birds may wander after dispersal and seem to travel nomadically. Adult birds, in contrast, migrate as needed when food becomes unavailable. Bald Eagles generally migrate alone but occasionally join other migrants on the wing, but not in kettles or flocks. Concentrations of migrants can occur at communal feeding and roost sites during migration. Migration tends to occur from August, with return to breeding grounds movements in January (Buehler 2000).

Bald Eagles hunt from perches or while soaring over suitable habitat. They attempt to take most prey on the wing (e.g., fish, waterfowl, small mammals) but success varies greatly. Eagles use carrion of fish, birds, and mammals extensively wherever encountered at sites that provide disturbance-free access from the ground. In most regions, Bald Eagles seek out aquatic habitats for foraging and prefer fish. They also use birds and mammals often as carrion, especially in winter. Bald Eagles obtain food by direct capture, scavenging (use of dead prey), and stealing food from other Bald Eagles, other birds, and mammals. To capture live prey, they soar overhead to visually locate the item, then suddenly stoop and attempt to capture such items with one or both feet. They will repeatedly stoop on waterfowl on the water but often with poor success. Most prey are taken to a nearby perch site for consumption, although small items may be consumed on the wing (Buehler 2000).

### Habitat Requirements

Typically breeds in forested areas adjacent to large bodies of water. Nests in trees, rarely on cliff faces and ground nests in treeless areas. Actual distance to water varies within and among populations. In some cases, distance to water is not as critical as the quality of the foraging area that is present. Quality of foraging areas defined by diversity, abundance, and vulnerability of the prey base, structure of aquatic habitat, such as the presence of shallow water, and absence of human development and disturbance. Diurnal perch habitat characterized by presence of tall, easily accessible, often super-canopy trees adjacent to shoreline foraging habitat, usually away from human disturbance. Perch-tree species used are highly variable, including both coniferous and deciduous species if present. Most perch trees used are live trees, although dead trees are preferred if available.

Bald Eagles winter primarily in temperate zones. Typically winter site locations are associated with aquatic habitats with some open water for foraging, although eagles may occur in arid regions of the Southwest. Bald Eagles often concentrate in large numbers (up to several thousand) on wintering grounds. Winter habitat suitability is defined by food availability, presence of roost sites that provide protection from inclement weather, and absence of human disturbance. Throughout its range, Bald Eagles select large, super-canopy roost trees that are open and accessible. Roost trees in eastern North America are deciduous or coniferous; most western roost trees are coniferous, except in some riparian zones.

### Seasonal Use/LNP Habitats

One nesting pair reside in the LNP during the spring and summer months, utilizing the artificial platform installed by UDWR staff. This pair has successfully raised 2 to 3 chicks each season for the past 11 years (UDWR 2006). More Bald Eagles use the LNP and surrounding properties during the winter months, roosting along the edges of the LNP mainly in cottonwood trees.

As a requirement of the USACE Section 404 permit and the USFWS, certain restrictive actions must be taken to protect the nesting Bald Eagles at LNP.

- No unauthorized human access within 1 mile of the Bald Eagle nest may occur during courtship, breeding, or nesting periods, from January 1 through May 21. Any required maintenance activities on LNP that fall within the 1-mile buffer must be minimal and follow the guidelines provided by the USFWS (see Appendix B. Eagle Nest Restrictions).
- From May 21 to August 31, no unauthorized human access may occur within 0.5 miles of the nest.
- A similar 0.5-mile buffer is required around all known Bald Eagle winter roosting sites on and surrounding LNP, from November 1 to March 31.
- Exceptions may occur on a case-by-case basis following approval from the USFWS.

### Habitat and/or Population Objectives

Population Objectives:

- Maintain the artificial nest platform and the breeding pair that uses it.
- Maintain continued use by wintering Bald Eagles.
- Keep human disturbance and presence to a minimum, particularly during the breeding/ nesting season in habitat surrounding the nest platform.

Habitat Objectives:

- Maintain and improve habitat within the 0.5-mile breeding buffer zone around the nest platform.
- Maintain snag trees and other roosting points for wintering Bald Eagles. One method is to plant appropriate tree species after consultation with an eagle ecologist/specialist.

### Habitat Management Strategy

See Chapter 5, Management Area (MA) Prescriptions.

### LNP Management Requirements

- Maintain artificial nest platform.
- Maintain buffer zone surrounding nest during breeding, nesting and fledging.

## *3.2.2. Black-necked Stilt (Himantopus mexicanus)*

### Associated Species

Other species that may respond similarly to habitat components used by Black-necked Stilt are Wilson's Phalarope, American Avocet, Long-billed Dowitcher, Marbled Godwit, Willet, Baird's Sandpiper, Least Sandpiper, Western Sandpiper, and Greater Yellowlegs.

## Distribution

Distribution of the Black-necked Stilt, like that of the American Avocet, is highly dependent on suitable local habitat, making the breeding range somewhat spotty and localized. Black-necked Stilt breed in North America in the western and west-central U.S., the Gulf and Atlantic coasts, Baja California, western Mexico, southwest-central Canada, and portions of the Bahamas and West Indies.

Breeding in Utah occurs on mudflats and shorelines in the wetlands associated with GSL, Utah Lake, the Bear, Little Bear, Logan, and Malad Rivers and BRMBR in northern Utah; the Uinta Basin at Ouray National Wildlife Refuge and other reservoirs in Uintah County; and at Fish Springs National Wildlife Refuge (Parrish et al. 2002). The Black-necked Stilt is a year-round resident in portions of Mexico.

A five-year survey of GSL yielded a mean of 25,522 stilts (July-September; Paul and Manning 2002). The number of individuals using the LNP is currently unknown and needs further investigation.

## Ecology (Robinson et al. 1999)

The primary foods for the Black-necked Stilt are invertebrates of the water column and flying insects near the water's surface including brine shrimp (Artemia), flies and fly larvae (Diptera), mosquitoes and midges (Chironomidae), terrestrial invertebrates including grasshoppers, small fish, crayfish, and seeds, especially sago pondweed and bulrushes. Stilts forage on bare ground and while wading in water depths of up to 6 inches, usually in water fresher than avocets prefer. They do not usually swim and forage as the avocet does. The stilt's principal hunting technique is pecking-seizing insects on or near the surface of the water or on land while standing still or walking slowly. Black-necked Stilts can be found foraging along the shallow boarders of freshwater and alkaline lakes, brackish ponds, salt marshes, and wet pastures (Parrish et al. 2002).

The birds arrive in Utah in early April. Very little information exists as to where and when pair formation occurs among stilts. Observations made in the 1970s suggest Black-necked Stilts do not form pair bonds until reaching the breeding grounds. Further observation notes that some stilts remain in pairs after the breeding season at migration stopovers; however, it is also noted that males and females differ in their migratory behavior on wintering ranges.

Stilts build their nests in loose colonies, sometimes with avocets. However, it appears that stilts will put more distance between their nest and other stilts than do avocets. Nest site selection is similar to that of avocets; very sparse vegetation in the area affording an unobstructed view all around. Nesting locations are generally on islands, when available, on dikes, or other areas associated with the water's edge. Nests are built on the ground, scraped into bare mud usually near patches of saltgrass or pickleweed, and then lined with small bits of weeds, grasses, twigs, shells, or bones. Average clutch size is four eggs. Incubation is shared by both sexes, alternating throughout the day and night, and lasts 22-26 days. Chicks are hatched precocial, downy, and able to feed themselves. After a day or two the parents move the brood to areas more suitable for feeding and hiding from predators. Similar to avocets, stilt juveniles will spend time in flocks with other stilts and depart for wintering grounds in small flocks beginning in August and throughout September. Stilts undergo molt of both body feathers and primaries during August and September.

## Habitat Requirements

Black-necked Stilts breed in fairly specific habitat regimes similar to the American Avocet. Nesting occurs in areas with salt ponds, potholes, or shallow alkaline wetlands. Nesting also occurs in some mudflats of inland lakes and impoundments and evaporation ponds. The alkaline wetlands are characterized by the presence of common cattail, bulrushes, and sedges; however, most time is spent in more open area with no vegetation or with sparse vegetation consisting of pickleweed, saltgrass, or greasewood. The birds feed in open water generally fresher than that of avocets from 0 to 6 inches deep, or on dry ground. The nests are usually built on islands or dikes with sparse vegetation. In desert wetlands, in Utah in particular, stilts nest along the lake shoreline among scattered patches of vegetation, along barren mudflats, or up on small patches of vegetation over water.

## Seasonal Use/LNP Habitats

As part of the GSL ecosystem, the LNP serves as an important breeding location for Black-necked Stilts. They arrive in April and may be found as late as November in the region. Their numbers peak in August, likely due to staging and post-breeding birds.

More details will be added to this section in subsequent updates as time permits. Updates may include which management units and habitat classifications are used by stilts at LNP, as well as survey data on the timing of use (arrival, departure, and peak dates).

## Habitat and/or Population Objectives

The current continental population is estimated at 150,000 (Brown et al. 2000). The Black-necked Stilt has been identified as a priority species in the UPF Plan (Parrish et al. 2002) and the Intermountain West regional shorebird plan (Oring et al. 2000). The Utah population objective is "to strive to maintain a breeding population of Black-necked Stilt of at least 25,000 pairs within the GSL ecosystem. Fall Staging Numbers should be at least 40,000 birds." (Parrish et al. 2002 p.133) The LNP's contribution toward the Utah objective will be the following:

Population Objective:

- Verify that there is a breeding population at the LNP and, if so, perform annual surveys to contribute to statewide data.

Habitat Objectives:

- Maintain or improve dikes and nesting islands in April and June as suitable nesting habitat, as well as mineral flats and non-vegetated or sparsely vegetated areas close to water with depths of 15–20 cm.
- Maintain or improve shallow emergent marsh habitats and vegetated mudflats (water depths of 0–6 inches) during peak migration to encourage use by migrating and staging stilts. Perform surveys of stilts staging at LNP to contribute to statewide data.

## Habitat Management Strategy

See Chapter 5, Management Area (MA) Prescriptions.

## LNP Management Requirements

None

### *3.2.3. AMERICAN AVOCET (RECURVIROSTRA AMERICANA)*

#### Associated Species

Other bird species that may respond similarly to habitat components used by American Avocet are Wilson's Phalarope, Black-necked Stilt, Long-billed Dowitcher, Marbled Godwit, Willet, Baird's Sandpiper, Least Sandpiper, and Western Sandpiper, and Greater Yellowlegs.

#### Distribution

The breeding range of the American Avocet lies in the western U.S. and in the southern prairie region of Canada (Ryser 1985). In the Great Basin, this species breeds in eastern Oregon, Honey and Mono Lakes in California, Humboldt and Carson Sink, Franklin and Ruby Lakes, and impoundments near Wendover in Nevada. In Utah, avocets breed at wetlands associated with GSL, and Bear and Snake Rivers in southern Idaho (Robinson et al. 1997).

Up to half of the individuals of this species breed in the Great Basin, and an even higher proportion of the continental population use the area for post-breeding molting and staging. Paul and Manning (2002) estimated 63,000 American Avocets were potential breeders at GSL. The average breeding population of avocets on the LNP is currently unknown. Detailed studies could easily be performed annually to estimate these numbers, and management of water levels as well as noxious weeds could improve and increase habitat favored by avocets.

Hundreds of thousands of avocets stage and molt at GSL in late summer/early fall with maximum counts of 250,000 (Paul et al. 1999). LNP, in cooperation with neighboring refuges along GSL, can be managed in order to maintain and improve habitat for staging and molting of avocets and other associated bird species.

#### Ecology (Robinson et al. 1997)

The primary foods for American Avocets are invertebrates of the water column and sediment, including water boatmen (Hemiptera, Corixidae), beetle larvae (Coleoptera), fly larvae (Diptera), and particularly midges (Chironomidae); terrestrial invertebrates include grasshoppers, caterpillars, and spiders. In the more saline wetlands in Utah, avocets also feed on brine shrimp and brine flies. Avocets forage while wading in water depths of 6-8 inches and while swimming in depths of up to 10 inches. Although scything is the hallmark method, avocets have flexible feeding behaviors. Avocets employ three visual feeding methods: pecking, plunging, and snatching; and several tactile feeding methods: bill pursuit, filtering, scraping, and single scything (bill is held open slightly at the muddy substrate surface and moved from side to side).

The birds arrive in Utah in late March. Pair formation seems to occur before and during migration, and is usually complete before the arrival at the breeding site. The nesting site is selected jointly after nest-searching and scraping displays. Selected sites are usually in very sparse vegetation in an area affording an unobstructed view. The nest is scraped into the substrate with the breast and feet by either sex. Clutch size is 3-4 eggs, and incubation averages 26.4 days. Both sexes incubate the eggs, alternating throughout the day and night. Chicks are hatched precocial, downy, and able to feed themselves. Young birds will remain in the nest for 24 hours after the last chick is hatched if undisturbed. The adults will then lead the chicks to a brood nursery area with shallow water and sufficient vegetation for cover. After approximately 27 days, the young avocets are capable of sustained flight, and spend their days in flocks with

other fledglings and adults. Avocets leave Utah for wintering grounds beginning in August and continue through September.

### Habitat Requirements

As evidenced by their spotty breeding range, American Avocets have fairly specific habitat regimes. Nesting occurs in areas with salt ponds, potholes, or shallow alkaline wetlands, as well as some mud flats of inland lakes and impoundments and evaporation ponds. Wetlands used by American Avocet are vegetated by common cattail (*Typha latifolia*), bulrushes (*Scirpus* spp.) or sedges (*Carex* spp.), but individuals spend most of their time in more open areas that have no vegetation, or that are characterized by glasswort (*Salicornia* spp.) saltgrass (*Distichlis* spp.), and even greasewood (*Sarcobatus* spp.) in more upland areas. American Avocets often nest on islands with relatively sparse vegetation or along dikes. Avocets nest in areas of islands and dikes with the least vegetation, usually along the slope or crown. In desert wetlands, avocets may nest on open salt pans near playas.

### Seasonal Use/LNP Habitats

Avocets utilize the LNP as a nesting, brood-rearing, and migration stopover.

More details will be added to this section in subsequent updates as they become available. Updates may include specific management units, habitat types, and locations of greatest use by avocets at LNP, as well as more detailed information about temporal and spatial use of LNP by American Avocets.

### Habitat and/or Population Objectives

The North American population estimate is 450,000 with a tentative target population of 450,000 (Brown et al. 2000). The American Avocet is considered a Bird of Conservation Concern in Bird Conservation Region 9, Great Basin (Pashley et al. 2000).

Population Objective:

- Maintain or increase American Avocet breeding population on the LNP. Current breeding totals are unknown and must be investigated.

Habitat Objectives:

- Maintain or increase nesting habitat consisting of dikes and nesting islands as suitable nesting habitat (mudflats and sparsely vegetated areas close to water depths of 6-8 inches).
- Create more nesting islands, as these are less likely to be destroyed by predation.
- Maintain or increase total acreage of emergent marsh at LNP (0-8 inches of standing water) and vegetated mudflat during peak shorebird migration, to encourage use by migrating avocets.

### Habitat Management Strategy

See Chapter 5, Management Area (MA) Prescriptions.

### LNP Management Requirements

None

### *3.2.4. WHITE-FACED IBIS (PLEGADIS CHIHI)*

#### Associated Species

Other bird species that may respond similarly to habitat components used by the White-faced Ibis are Snowy Egret, Forster's Tern, Franklin's Gull, Redhead, Black-crowned Night Heron, Great Blue Heron, Western Grebe, Clark's Grebe, Eared Grebe, American Bittern, Long-billed Curlew, Red-winged Blackbird, and Yellow-headed Blackbird.

#### Distribution (Ryder and Manry 1994)

The White-faced Ibis has a continuous distribution. It is locally common, nesting in several marshes in the western U.S., especially in the Great Basin, and wintering in large flocks in Mexico, western Louisiana, and eastern Texas. The largest breeding colonies are usually located in Utah, Nevada, Oregon, and coastal Texas and Louisiana. Around the Great Basin, ibis are located at GSL, at Ruby and Utah Lakes, in the Carson Lake-Stillwater area, at Honey Lake, and at Malheur National Wildlife Refuge (Ryser 1985).

Average breeding White-faced Ibis populations for the LNP are currently unknown. Future nesting surveys at LNP will be necessary to determine the level of use by ibis.

#### Ecology (Ryder and Manry 1994)

White-faced Ibis frequent shallowly flooded pond margins, reservoirs, and marshes. In Nevada, they feed in recently flooded agricultural fields where vegetation is 2–35 inches tall. Their long legs, neck, and recurved bill facilitate foraging, as these birds wade in shallow water or traverse moist soil. Prey on the surface of water or soil are located visually, while prey below the soil surface are captured by tactile probing. Two aquatic feeding methods have been identified for the White-faced Ibis: 1) a "ranging" method, in which the ibis walks back and forth and probes the water like a "pecking chicken," and 2) stationary methods, in which the ibis stands in one place and swings its bill side-to-side. One author believes the ranging method is used to capture crayfish (Decapoda), beetles (Coleoptera), or other adult insects, whereas a stationary method is used to catch midge (Diptera) larvae. Aquatic and moist-soil invertebrates, especially earthworms and larval insects (mainly Orthoptera, Odonata, Hemiptera, Coleoptera, and Diptera) are major food items. They also take leeches and snails.

In northern Utah, pair formation and nest-site selection occur mostly mid-April to mid-May, shortly after ibis arrive from wintering areas. Eggs are laid from the last week of April through the second week of June. Mean clutch completion dates are between May 14 and 20 (Kotter 1970). Ibis are colony nesters and some colony sites are used repeatedly over several years. This species usually nests in emergent vegetation or low trees and shrubs over shallow water; sometimes on the ground on small islands. In a Utah colony, nests ranged between 8 and 39 inches above water 24 inches deep. Average clutch size for the region is 4 eggs. Incubation on average is 20 days for the last egg in the clutch and up to 26 days for the first-laid egg. Both sexes are thought to incubate. Young are altricial, wet upon emergence but dry within 2-3 hours. By day nine, the young can climb out of the nest and wander for short distances. By week four, the nestling is well covered with juvenile feathers. Young are fed directly by adults by crouching over the nest and lowering their partly-open bill into the nest cup. Chicks insert their heads into the adult's mouth to feed on regurgitated food. Young are essentially independent at eight weeks.

### Habitat Requirements

This species inhabits primarily freshwater wetlands, especially cattail (*Typha* spp.), and bulrush (*Scirpus* spp.) marshes, although it feeds in flooded hay meadows, agricultural fields, and estuarine wetlands. In the Great Basin, the largest colonies are in stands of hardstem bulrush (*Scirpus acutus*), Olney's bulrush (*S. olenyi*), and alkali bulrush (*S. paludosus*). Ibis frequently feed in shallowly flooded wetlands of short, emergent plants. Dominant plants are sedges (*Carex* spp.), and spikerushes (*Elocharis* spp.) as well as salt-tolerant glassworts (*Salicornia* spp.), saltgrass (*Distichlis spicata*), and greasewood (*Sarcobatus vermiculatus*). Nearby irrigated crops, particularly alfalfa, barley, and native hay meadows, are important feeding sites in Nevada, Colorado, Utah, Idaho, and Oregon.

### Seasonal Use/LNP Habitats

White-faced Ibis may be present from April through September and use wet mudflats, wet meadows, and shallow emergent marshes for feeding and staging. White-faced Ibis use mid-depth emergent (8-12 inches) and deep emergent (12-24 inches) marshes from May through July for nesting, mainly in hardstem bulrush dominated aquatic plant communities.

Specific nesting sites at LNP have not yet been discovered and will need further survey work.

### Habitat and/or Population Objectives

The North American population is estimated at more than 100,000 breeding pairs. The Great Basin population estimate is 25,908 individuals. Objectives for Utah are to maintain 10,000 breeding pairs in Utah (Ivey and Herziger 2003).

Population Objective:

- Maintain any breeding colonies of ibis on the LNP; record number of nests annually to track changes.

Habitat Objectives:

- Provide shallow emergent marsh and mid-depth emergent marsh for suitable nesting habitat (May-June). As White-faced Ibis prefer hardstem bulrush stands for nesting, this objective may be refined after further field investigations to report the optimal acreage of bulrush stands. The size of bulrush patches and likely stem density affects suitability as a colony site, likely due to cover from predators.
- Provide wet meadow and salt meadow habitat for foraging sites from April through September.
- Maintain shallow emergent marsh and shallow submergent marsh throughout the period of April to September for foraging and staging White-faced Ibis.

### Habitat Management Strategy

See Chapter 5, Management Area (MA) Prescriptions.

### LNP Management Requirements

None

### *3.2.5. FORSTER'S TERN (STERNA FORSTERI)*

#### Associated Species

Other species that may respond similarly to habitat components used by Forster's Terns are Yellow-headed Blackbird, Red-winged Blackbird, Mallard, Black Tern, White-faced Ibis, Sora, and Virginia Rail.

#### Distribution

Forster's Tern's highest breeding numbers are found around south-central Manitoba, northern California, southern Oregon, and the Gulf Coast. Its centers of abundance in early winter match those of its coastal breeding areas, particularly around the Virginia-North Carolina border, in Galveston Bay (Texas), and near Jacksonville, Florida. In Utah, Forster's Terns are at the southeastern edge of their distribution for the Great Basin at GSL.

#### Ecology (McNicholl et al. 2001)

Forster's Tern is the only tern restricted almost entirely to North America throughout the year. Pair bonding seems to happen immediately before or upon arrival at the breeding grounds in spring. During pair bonding and courtship, nest-building behaviors begin, with nesting generally occurring from early May through July. Forster's Terns do not typically have more than one clutch per season, but will renest after destruction of the nest either by predation or changes in water levels. In freshwater marshes, terns usually nest on the ground within clumps of vegetation, often adjacent or close to open water, on marshy shores of lakes, or on heaps of washed-up or floating dead vegetation. Clutch size is typically 2-3 eggs. Both adults incubate eggs for a period of approximately 25 days.

All inland breeding locations tend to be deserted during the winter. Forster's Terns also tend to display post-breeding dispersal to areas north and south of breeding areas. For their first summer, most immature terns remain within the species' wintering distribution, which is southern coastal U.S and Mexico. Migration timing is not directly known for the GSL region; however, terns breeding along coastal California begin migration as early as late June, while more interior populations tend to migrate later in August and September. Forster's Terns tend to migrate in small groups rather than in larger flocks.

Forster's Terns primarily feed on small (1-4 inch) fish, and some arthropods.

Foraging habitat includes marshes, lakes, water channels and in shallow, saltwater estuaries and coastal areas. Terns forage throughout marshes in which they breed, in saltwater coastal areas, in shallow water (less than 3 feet) over flood-tide mudflats, or in areas of calm water offering high visibility. While foraging, terns fly back and forth over water with their bill pointing downward and feet folded against their body, typically approximately 18–25 feet above water, and either plunge directly into water towards prey or hover briefly (3–4 s) before diving. Plunges are typically shallow with only bill and part of the head submerged, but sometimes an individual's whole body is completely submerged. Forster's Terns will sometimes forage from perches such as posts, bridges, telephone wires, or floating boards.

#### Habitat Requirements

As a marsh tern, this species breeds primarily in fresh, brackish, and saltwater marshes, including marshy borders of lakes, islands, or streams. It is found more often in open, deeper portions of

marshes, generally in wetlands with considerable open water and large stands of island-like vegetation and/or large mats of floating vegetation. The suitability of nesting habitat is often ephemeral, varying at a given site from year to year. In freshwater marshes, nests are built on muskrat lodges or on mats of floating vegetation comprising various species, including algae, cattails (*Typha* spp.), bur-reed (*Sparganium* spp.), arrowhead (*Sagittaria* spp.), bulrush (*Schoenoplectus* spp.), phragmites (*Phragmites australis*), sedge (*Carex* spp.), water lilies (*Nymphaea* spp.), and bladderwort (*Utricularia* spp.). It forages in habitats similar to its nesting habitat, including marshes, lakes, and water channels, and in shallow, saltwater estuaries and coastal areas.

### Seasonal Use/LNP Habitats

The LNP appears to have a small colony of Forster's Terns in the salt-affected floodplain. The success of this colony is entirely dependent upon the persistence of shallow emergent marsh; thus, this habitat type may need to be manipulated and/or maintained in dry years in order to provide the appropriate nesting habitat for the duration of the nesting season. Actual breeding at LNP still needs to be verified with nest searches; as the Forster's Terns are consistently seen at LNP during the spring and summer months, and may be using the area for feeding, while nesting on adjacent properties. Terns also use LNP habitats for early parts of staging and migration.

### Habitat and/or Population Objectives

Tern species in general are a good "umbrella" or indicator species of habitat health, and their presence at LNP should therefore be considered for monitoring, maintenance, and improvement.

Population Objectives:

- Confirm and maintain any nesting colonies of Forster's Tern at LNP.
- Maintain any feeding or staging populations using the LNP.

Habitat Objective:

- Maintain appropriate nesting and feeding habitat for terns, including open and shallow emergent freshwater wetlands.

### Habitat Management Strategy

See Chapter 5, Management Area (MA) Prescriptions.

### LNP Management Requirements

None

## *3.2.6. Long-billed Curlew (Numenius americanus)*

### Associated Species

Other species that may respond similarly to habitat components used by the Long-billed Curlew are Willet, Wilson's Phalarope, Western Meadowlark, and other upland grassland birds.

### Distribution

Long-billed Curlews breed from south-central British Columbia, southern Alberta, southern Saskatchewan, and southern Manitoba south to east-central California, central Nevada, central

Utah, central New Mexico, northern Texas, and east to southwest North Dakota, northwest North Dakota, north-central Nebraska, and southwest Kansas. They winter from Washington, extreme northern Mexico, southern Texas, southern Louisiana, southern Alabama, and coastal South Carolina south to southern Mexico.

The Long-billed Curlew is a fairly common summer resident and migrant in Utah, especially through the central and more northern valleys (Parrish et al. 2002). A five-year survey of GSL found a mean of 125 Long-billed Curlews from April through June (Paul and Manning 2002). There have been anecdotal observations in the past of curlews using the LNP, perhaps because cattle grazing was present to create suitable shortgrass habitat.

### Ecology (Dugger and Dugger 2002)

In Utah, most Long-billed Curlews that nest around GSL start to arrive on the breeding ground during the last week of March and establish territories by mid-April. Birds in northern Utah arrive later and remain longer than curlews in other parts of its range, probably as a result of climate differences. Foods taken are diverse, including crustaceans, mollusks, worms, toads, the adults and larvae of insects, sometimes berries, and/or the young of nesting birds. The Long-billed Curlew forages by probing and pecking. Clutch initiation dates also vary with climate, and in northern Utah start from mid-April to mid-May. Nests found in Box Elder and Cache Counties, Utah, were typically a grass-lined depression located in a clump of grass. Female curlews are monogamous and lay only one clutch each season. Clutch size is typically 4 eggs. Young are precocial and tended by both adults.

In western Idaho, mammalian carnivores were the most important predators of curlew eggs and clutches. Survival of very young chicks (0-5 days) probably depends more on their learning to feed effectively and receiving occasional thermoregulatory assistance from parents than on avoiding predation. There is a bias in natal philopatry in male curlews, but they do not return and attempt to breed until they are 3 or more years of age. Females breed for the first time at age 2-3 years. Average adult survival is approximately 85% per year, and the average longevity may be 8-10 years.

### Habitat Requirements

Long-billed Curlews have 4 essential nesting habitat requirements in the northwestern U.S.: 1) short grass (less than 12 inches), 2) bare ground components, 3) shade, and 4) abundant vertebrate prey. Curlews seem to be most successful in mixed fields with adequate, but not tall, grass cover and fields with elevated points. Uncultivated rangelands and pastures support most of the continental Long-billed Curlew's breeding population. Curlews tend to place their nests near manure piles or other conspicuous objects, camouflaging them from aerial predators. At GSL, the ground is relatively level, and curlews prefer to nest near the edges of barren alkali flats. They prefer firm mud substrate or high-tidal areas to soft mud, sand, or low-tidal areas for foraging. Moist, firm mud (water less than 0.5 inches deep) are used most during all seasons, and use increased from 50% in fall to 100% in spring. Use of wet mud habitats (0.7–5.0 inches deep) declined during the same period. During breeding in Colorado, 55% of foraging observations occurred in short grass, 40% in crop fields. In Oregon, Long-billed Curlews used cheatgrass, (*Bromus* spp.), and freshly mowed alfalfa.

### Seasonal Use/LNP Habitats

Based on anecdotal accounts from previous years, curlews use the LNP, though it is unclear which activities the LNP is used for. Recent bird surveys have not recorded the presence of any curlew, potentially due to changes in habitat and grass height in particular following the removal of cattle grazing.

More details will be added to this section in subsequent updates as time permits. Updates may include any sightings of curlews at the LNP, which management units historically contained curlew, and timing of use (arrival, departure, and peak dates).

### Habitat and/or Population Objectives

The continental population estimate is 20,000, with a tentative target of 28,500 (Brown et al. 2000). It is considered a species of Conservation Concern by the Mountain-Prairie Region (6) of the Service and Bird Conservation Region, Great Basin (Pashley et al. 2000), and a UPF, Priority Species in Utah (Parrish et al. 2002).

Population Objective:

- Encourage return of historic breeding and/or staging population levels previously noted on LNP.

Habitat Objectives:

- Maintain mudflats for potential nesting and foraging habitat (May-June; August-September).
- Provide wet meadow and salt meadow for foraging habitat (May-June; August-September).

### Habitat Management Strategy

See Chapter 5, Management Area (MA) Prescriptions.

### LNP Management Requirements

None

## *3.2.7. Grasshopper Sparrow (Ammodramus savannarum)*

### Associated Species

Other species that may respond similarly to habitat components used by Grasshopper Sparrows are Western Meadowlark, Horned Lark, Cinnamon Teal, Short-eared Owl, and White-faced Ibis.

### Distribution

The Grasshopper Sparrow has an isolated summer range in the West that includes the GSL region, parts of southern Idaho, and southwestern Wyoming. Thus, this sparrow is included as a potential nesting species at the LNP, though this has not yet been confirmed by breeding bird surveys or nest searches. The sparrow has been recorded during transect surveys using the grassland and alkaline knolls habitats at LNP.

### Ecology (Vickery 1996)

A small, inconspicuous grassland bird with an insect-like song, the Grasshopper Sparrow is easily overlooked. Pairs form on breeding grounds in early May, immediately after arrival of females; males arrive 3–5 days earlier to establish territories. In general, breeding season for Grasshopper Sparrows is protracted; depending on favorable weather, the species can produce at least 2 broods annually, even in the northern portions of the range. This is critical for a ground-nesting species that generally experiences moderate to high levels of nest predation.

Grasshopper Sparrows have a distinct ground nest that is very difficult to locate, usually domed with overhanging grasses with a side entrance, somewhat similar to an Ovenbird (*Seiurus aurocapilla*) nest. Nests are built and all incubation is done by the female. Incubation takes 11-13 days, with average clutch sizes of 4 or 5 eggs. If flushed from the nest, the female often performs an injury distraction display.

Grasshopper Sparrows forage exclusively on the ground, in breeding months feeding on mostly insects. They prefer grasshoppers (Orthoptera). In winter, they primarily consume seeds, especially panic grass (*Panicum* spp.) and sedges (Cyperaceae). Most capture attempts for prey are aimed at grasshoppers, which they grab by the thorax, paralyzing their prey.

### Habitat Requirements

In the breeding season, this sparrow generally occupies intermediate grassland habitat, preferring drier, sparser sites in lush tallgrass prairies and eastern grasslands, and thicker, brushier sites in shortgrass prairie and southwestern grasslands. Generally speaking, the Grasshopper Sparrow prefers moderately open grasslands and prairies with patchy bare ground from which it selects different components of vegetation, depending on grassland ecosystem. They are more likely to occupy large tracts of habitat than small fragments. Habitat, therefore, is usually the limiting factor for Grasshopper Sparrow populations, rather than food limitations or inter-specific competition.

### Seasonal Use/LNP Habitats

Grasshopper Sparrows have been positively identified by sight and song during LNP breeding bird surveys. Currently there is no estimate of the number of breeding pairs at the LNP; however, territorial songs can be heard in more than one habitat at LNP, most commonly in the alkaline knolls and grassland habitats. Grasshopper Sparrows winter mainly in Mexico and Central America, and little is known about their staging or migration status at LNP.

### Habitat and/or Population Objectives

Breeding bird survey data show an annual decline of 3.9% throughout North America for the period 1966–1994, with the average decline in the western U.S. even greater, at 4.5%. These declines are attributed to loss of habitat, particularly conversion of pasture to intensive row crops and inhibition of fire. This species is listed as a priority species by UPF and as a species of concern by the UDWR.

This species responds favorably to habitat improvements, including prescribed burning (post-breeding, and cool enough to leave some scrub cover), light to moderate grazing, and late-season mowing. Each has different impacts depending on the type of grassland ecosystem.

Population Objective:

- Encourage continued presence and breeding pairs at LNP. Currently, number of breeding pairs at LNP is unknown.

Habitat Objectives:

- Maintain or improve shortgrass/scrub habitat for breeding Grasshopper Sparrows.
- Control predator numbers to protect this ground-nesting species.

### Habitat Management Strategy

See Chapter 5, Management Area (MA) Prescriptions.

### LNP Management Requirements

None

## *3.2.8. BURROWING OWL (ATHENE CUNICULARIA)*

### Associated Species

Other species that may respond similarly to habitat components used by Burrowing Owl are Long-billed Curlew, Short-Eared Owl, Western Meadowlark, and other upland grassland birds.

### Distribution

Breeds from the Central Plains states north into Canada, west to grassland portions of Washington and Oregon, and south through California and Mexico. Burrowing Owls are also year-round residents of portions of Florida and the Caribbean.

### Ecology (Haug et al. 1993)

The Zuni Indians called this owl the "priest of the prairie dogs" because it frequently nests and roosts in empty prairie dog burrows, and early European settlers were convinced that rattlesnakes often shared its nests. Unique among North American owls in many respects, this bird is active day and night and frequently nests in loose colonies in suburban and farmyard environments, making it a familiar owl and one generally appreciated by human residents. Though livestock grazing can be beneficial to Burrowing Owls, farming has taken a major toll on the bird and its habitat, destroying nesting burrows and exposing breeders and their young to the toxic effects of pesticides. Several introduction programs, combined with the use of artificial burrows, have helped to counter these threats.

Nesting begins in early April, and as their name implies, Burrowing Owls nest underground, often in the abandoned burrows or dens of mammals, often surrounded by shorter vegetation to facilitate in guarding/sentinel behavior of adults. Nest and entrance are often lined with dried livestock dung. Clutches are usually 6-11 eggs, and are incubated for 28-30 days by the female only. Males seek out food and deliver meals to the female in the early morning and late evening; female tears off pieces and feeds to young once they are hatched. Young are altricial and need parental care and protection for up to two months.

Burrowing Owls are opportunistic feeders, consuming primarily arthropods, small mammals, birds, and occasionally amphibians or reptiles. Insects are more often taken during daylight hours, with small mammals taken more often at dusk or after dark. Burrowing Owls hunt by walking, hopping, or running along the ground, flying from a perch, hovering over tall

vegetation, and fly-catching in the air. Prey is usually caught with the feet, but may be transferred to the beak for carrying or presentation to young.

### Habitat Requirements

Burrowing Owls prefer dry, open, shortgrass, treeless plains, often associated with burrowing mammals. They will also occupy golf courses, cemeteries, road allowances within cities, airports, vacant lots in residential areas and university campuses, and fairgrounds. The presence of a nest burrow seems to be the critical requirement for the western Burrowing Owl. Food supply (ample invertebrates and small mammals) is also essential.

### Seasonal Use/LNP Habitats

Based on accounts from previous naturalists at LNP, Burrowing Owls were sighted along dikes in the alkaline knolls habitat, possibly associated with abandoned fox dens in the area. Burrowing Owls are also well established at a neighboring gun club property, due to the installation of artificial nest burrows.

### Habitat and/or Population Objectives

The owl is considered a priority species by UPF (Parrish et al. 2002). It is also listed in many surrounding states, including Wyoming, Idaho, and North and South Dakota. Population declines are evident in most areas where Burrowing Owls are studied, due mostly to habitat destruction, pesticides, predators, and vehicle collisions.

Population Objective:

- Encourage return of historic breeding populations, with expectations of supporting 5 or more pairs of Burrowing Owl.

Habitat Objective:

- Improve shortgrass habitat within the alkaline knolls habitat by mowing or grazing.
- Provide artificial nest sites if natural burrows abandoned by fox are inadequate.

### Habitat Management Strategy

See Chapter 5, Management Area (MA) Prescriptions.

### LNP Management Requirements

None

## *3.2.9. WILSON'S PHALAROPE (PHALAROPUS TRICOLOR)*

### Associated Species

Other species that may respond similarly to habitat components used by the Wilson's Phalarope are Western Meadowlark, Cinnamon Teal, Short-eared Owl, White-faced Ibis, and Marbled Godwit.

### Distribution

Unlike other phalarope species, Wilson's Phalarope breeds exclusively within the Nearctic, and its non-breeding distribution is entirely continental. This species winters in Bolivia and

Argentina. Breeding range includes wetlands of the western provinces and states. This phalarope is a common, often abundant breeding species in the Great Basin (Ryser 1985).

GSL is considered a critical staging area for Wilson's Phalarope, with estimates in excess of 500,000 (Jehl 1988). The goal for LNP is to play a contributing role, along with other preserves and refuges, in maintaining suitable staging and migration habitat for Wilson's Phalarope.

### Ecology (Colwell and Jehl 1994)

Wilson's Phalarope are known for their reversed sex-role mating system. Larger and more brightly plumaged females compete for mates and are sometimes polyandrous, whereas males provide all parental care. Following courtship displays, females will lay around 4 eggs in a bare scrape and the male lines the scrape with vegetation during the subsequent 3-4 days. Males appear to pull and shape a vegetation canopy over the nest. Males then incubate eggs for approximately 23 days before hatching. The young leave the nest within 24 hours of hatching and are capable of feeding themselves. Peak of clutch initiation in Saskatchewan was late May to early June.

After the breeding season, virtually all adults undertake a molt migration and stage, often in huge flocks, at hyper-saline/alkaline lakes of western North America, before migrating to similar wintering habitats mainly in Bolivia and Argentina. Southward migration of adults is characterized by rapid and direct nonstop fight from staging areas in the U.S. to coastal western South America. Sex differences in habitat use vary seasonally. During incubation and brood rearing periods, males use a wider array of aquatic and terrestrial habitats; females use more aquatic habitats. Throughout the staging period, females typically forage aquatically, spearing brine shrimp and brine flies from the water's surface. In contrast, the males and juveniles are more terrestrial, foraging early on brine flies on or near the lakeshore, but later becoming highly aquatic and (males) taking more shrimp (Colwell and Jehl 1994).

This phalarope whirls in tight circles in shallow or deep water, picking invertebrates from the water's surface or just below it. On land, Wilson's Phalarope makes short jabs to pick up food in open areas. An overview of the diet includes Diptera, Heteroptera, Coleoptera, and Crustacea. At GSL, diet indicates sex and age differences, with adult females feeding on brine shrimp (21% by volume), brine flies (70%), and other aquatic invertebrates (10%). Adult males feed on brine flies (75%) and aquatic invertebrates (25%). Juveniles only feed on brine flies.

### Habitat Requirements

The Wilson's Phalarope breeds at shallow wetlands of interior western North America, but for most of the year is a salt-lake specialist. This species nests in sparse vegetation of uplands (e.g., *Poa* spp.), marshes (e.g., *Juncus balticus, Triglochin maritima*), and roadside ditches (*Hordeum jubatum*). Nests are located within 300 feet of wetlands in taller, denser, and more heterogeneous vegetation (e.g., *Juncus balticus, Distichlis spicata, Triglochin maritima*), compared with random sites and surrounding vegetation. Phalaropes forage in open-water and flooded meadows, less frequently in upland habitats and along beaches. Wilson's Phalaropes often occupied the peripheral low-prairie and wet-meadow areas of most classes of wetlands in North Dakota. Wilson's Phalarope are associated negatively with wetlands dominated by thick-stemmed plants, e.g., cattails (*Typha* spp.) and river bulrush (*Schoenoplectus fluviatilis*).

### Seasonal Use/LNP Habitats

The LNP, as part of the GSL ecosystem, is important for migrating and staging Wilson's Phalarope and may even provide nesting habitat during the summer season. During the breeding season, they utilize salt and wet meadow habitats. They exploit shallow submergent, shallow emergent, and mid-depth emergent wetlands for foraging and staging.

More details will be added to this section in subsequent updates. Updates may include which LNP management units the species has historically used and currently uses and the timing of use (arrival, late and peak dates).

### Habitat and/or Population Objectives

Population Objectives:

- Help to maintain overall breeding population as part of the GSL ecosystem.
- Help to maintain populations of staging and migrating Wilson's Phalarope.

Habitat Objectives:

- Maintain salt and wet meadow habitat for breeding (May-June).
- Maintain shallow submergent, mid-depth submergent, and shallow emergent habitats for foraging and staging (July-September).

### Habitat Management Strategy

See Chapter 5, Management Area (MA) Prescriptions.

### LNP Management Requirements

None

## *3.2.10. Cinnamon Teal (Anas cyanoptera septentrionalium)*

### Associated Species

Other bird species that may respond similarly to habitat components used by Cinnamon Teal are Mallard, Gadwall, Northern Pintail, Green-winged Teal, Blue-winged Teal, Northern Shoveler, White-faced Ibis, Long-billed Curlew, Willet, Wilson's Phalarope, Western Meadowlark, Northern Harrier, Short-eared Owl, Horned Lark, Vesper, and Savannah Sparrow.

### Distribution

Though there are five subspecies of Cinnamon Teal, only one—*A. cyanoptera* subsp. *septentrionalium*—breeds in North America. This subspecies breeds primarily in the Great Basin and Intermountain West regions of the U.S. and winters mainly on coastal marshes and interior wetlands in Mexico. Over half of the total North American population is said to breed in the marshes east and north of GSL in Utah (Bellrose 1980). Important breeding areas include GSL and surrounding marshes in Utah; Malheur Lake, Summer Lake, and Klamath marshes in Oregon; and Ruby Lake and Carson Sink in Nevada.

Results of a five-year survey of the GSL region showed a mean population of 16,795 Cinnamon Teal for the period of August through September (Paul and Manning 2002). Cinnamon Teal are known to nest at the LNP, but total numbers have yet to be surveyed or researched.

### Ecology (Gammonley 1996)

Cinnamon Teal are seasonally monogamous, with most pairs forming before arriving on breeding areas. Females lay 4 to 16 eggs in a well-concealed nest near water in rushes, sedges, and grasses, or sometimes over water in dense bulrushes or cattails. Nests are often placed below matted, dead stems of vegetation so that the nest is completely concealed on all sides and above; the female approaches through tunnels in vegetation. After 21-25 days of incubation, chicks are hatched precocial and down-covered. Within 24 hours, the chicks will follow the hen directly to nearest water. Males remain with their mates until late incubation and guard females and sometimes sites within wetlands near the nests. After breeding, molting males form small flocks on nearby wetlands or perform molt migrations to large marshes with abundant emergent vegetation. Females perform all brood-rearing duties, and usually remain with their young through fledging. Hens with broods use seasonal and semi-permanent wetlands with abundant emergent cover. Broods often feed over dense submergent vegetation in deeper portions of semi-permanent wetlands. Breeding period in Utah is late April to late July.

An omnivorous species, the Cinnamon Teal feeds primarily by dabbling in shallowly flooded zones (less than 8 inches) along wetland margins; in deeper water, it feeds at the surface or in emergent or submergent vegetation. Seeds of hardstem bulrush, alkali bulrush, and smartweed (*Polygonum* spp.), are common in the diet in all seasons and provide a high-energy food source. To meet the protein costs associated with egg production, females increase their consumption of aquatic insects (Chironomidae and Corixidae), snails (Gastropods), and zooplankton (Cladocera) from spring migration through egg laying.

### Habitat Requirements

Cinnamon Teal use freshwater (including highly alkaline), seasonal, and semi-permanent wetlands of various sizes, including large marsh systems, natural basins, reservoirs, sluggish streams, ditches, and stock ponds. It appears to prefer basins with well-developed stands of emergent vegetation and uses emergent zones to a greater extent than open-water portions of basins. It nests near water in low, dense, perennial vegetation such as Baltic rush (*Juncus balticus*), saltgrass (*Distichlis spicata*), spikerush (*Eleocharis macrostachya*), tufted hairgrass (*Deschampsia caespitosa*), western wheatgrass (*Pascopyrum smithii*), foxtail barley (*Hordeum jubatum*), and various forbs; less often at base of greasewood (*Sarcobatus vermiculatus*) and other shrubs; and over emergent marsh vegetation. It feeds primarily by dabbling in shallowly flooded zones (less than 8 inches) along wetland margins.

### Seasonal Use/LNP Habitats

Cinnamon Teal nest in the upland habitats and utilize freshwater marsh and riparian LNP habitats for foraging and molting (see Table 3.3). They are present at LNP from March through November.

More details will be added to this section in subsequent updates. Updates may include which management units this species has been recorded in from bird transect surveys and timing of use.

### Habitat and/or Population Objectives

An accurate continental population estimate is unavailable, though data suggest a population size of 260,00–300,000. This estimate makes the Cinnamon Teal one of the least abundant dabbling ducks in North America (Gammonley 1996).

Population Objectives:

- Support breeding pairs of Cinnamon Teal on the LNP and conduct annual nest surveys to estimate total number of pairs using LNP.
- Support staging and molting populations (August).
- Conduct surveys to estimate total number of individuals staging at LNP.

Habitat Objectives:

- Maintain or improve dike and salt meadow habitats throughout the nesting season (April–July) for breeding habitat.
- Maintain or improve total acreage of shallow emergent (2-8 inches) habitat for foraging, brood rearing and molting Cinnamon Teal (June–August).

### Habitat Management Strategy

See Chapter 5, Management Area (MA) Prescriptions.

### LNP Management Requirements

None

## 3.3. LANDSCAPE-SCALE RESEARCH NEEDS FOR PRIORITY BIRD SPECIES

In addition to potential species-specific data on population, density, nesting location, artificial nest use, etc., that could be gathered using modified bird monitoring protocols, researchers have also identified landscape-level research needs. These topics have been identified in the literature and do not necessarily prioritize the research agenda for the LNP:

- Determine and describe migratory routes as well as winter sites in Mexico.
- Investigate and identify interactions among water quality and quantity, invertebrates, plants, and birds in the Great Basin ecosystems.
- Investigate energetics and nutrition.
- Determine adult survival rates.
- Identify and develop habitat management techniques specifically aimed at increasing productivity.
- Determine impacts of irrigation drain water contamination on adults and juveniles.
- Develop statistically valid monitoring protocol to determine reproductive success (e.g., young per nest, nesting success rate, and fledgling survival rates).
- Determine the importance of brine flies and brine shrimp to shorebirds and waterbirds of GSL.
- Determine importance of the GSL ecosystem in staging and migration if not currently available.
- Identify breeding pair density within the greater GSL ecosystem.
- Develop technique to implement rangewide breeding surveys.

- Investigate management effects (e.g., grazing, water level manipulation).
- Determine annual and seasonal survival rates of chicks, subadults, and adults.
- Quantify success rates of various management strategies (e.g., artificial nest boxes, artificial perches, pesticide restrictions).
- Quantify return rate of young to natal colony, habitat, or region.

Additional considerations such as time, funding, available expertise, and complementary local and region research goals should also inform the long-term use of the LNP as a study site.

## 3.4. PRIORITY SPECIES AND HABITAT MANAGEMENT

The habitat management strategies to achieve objectives listed in the priority species summaries can be found in Chapter 5. Habitat objectives were derived by linking species-specific habitat needs to the type and amount of habitats available at LNP. Historic and current LNP habitat use and distribution data were used as a guide.

LNP staff and supervisory committee will select the most appropriate management strategies during the annual habitat management planning process. Strategies will be selected after evaluation of:

- the previous year's monitoring data,
- past and predicted response by priority species,
- the ranking order of the priority species,
- consideration of current habitat conditions,
- current and forecasted management prescriptions, and
- special management concerns (e.g., invasive species, mitigation requirements).

## 3.5. RESOLVING CONFLICTS WITH HABITAT NEEDS FOR LNP RESOURCES OF CONCERN

In a typical water year, LNP has the capacity to meet the habitat needs for the designated priority species. A complex of different wetland habitat types can be provided through the manipulation of water levels in the different management units by way of water conveyance structures that have been constructed throughout LNP. The management of water levels influences aquatic invertebrate and plant species diversity, abundance, production, and colonization. Upland nesting habitat may be managed through reseeding, mowing and/or grazing during the non-breeding season, to attain climax plant communities based on soil types. Climax communities will provide nesting species with optimal concealment cover and foraging opportunity.

During low-water years, however, LNP is likely to focus on the needs of spring and fall migrants, as the availability and timing of water inflows are a limiting factor. In summer months with low water inflow, the LNP may be unable to keep water levels stable to offset losses due to evaporation. As a consequence, most units may be allowed to dry out, with the remaining water and small amount of inflow water being diverted to the MAs with the highest priority. The two highest priority MAs are the Evaporative Basins and Riverine MAs, as they receive the greatest use by priority species.

The management units within LNP will be reviewed and prioritized annually. Prioritization is based on current and historic use by priority breeding birds, breeding bird density, and priority breeding bird diversity, as well as aquatic plant community succession, productivity, structure, and density.

Though unit priorities are largely influenced by water flows each spring, LNP staff may occasionally be expected to diverge from established priority goals to adapt to events such as disease outbreaks or unexpected vegetative responses to management, or to undertake maintenance activities. If necessary, temporary losses of habitat in a particular management unit may be offset by adjusting objectives within other units.

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# CHAPTER 4. GENERAL MANAGEMENT PRESCRIPTIONS

## 4.1. HABITAT GOALS AND OBJECTIVES

The overall goal for LNP habitat management is to provide a spatial and temporal distribution of native and desirable habitats that meet the breeding, feeding, and resting needs for species using the LNP, with an emphasis on supporting priority bird species. To reach that goal, habitat management will aim for a complex of wetland and upland types with varying water depths, diverse plant communities, and an abundance of aquatic invertebrates for foraging, resting, and staging birds.

At the same time, managers working within the LNP must take into consideration any constraints and limitations that may arise on a case-by-case basis and not prioritize habitats within the LNP that are too small to successfully support viable populations of particular flora or fauna. Cooperative work with neighboring wildlife management areas will be an asset in cases where particular habitat types may be limited at LNP.

## 4.2. MANAGEMENT TOPICS

This section contains descriptions of feasible prescriptions that may be used to manage habitats at LNP. Prescriptions are categorized by topic (e.g., weed, water, predator management) with a statement of LNP's management objective, followed by a list of potential strategies that may be used to manage each issue. Actual prescription options for each of the LNP's MAs will be discussed in Chapter 5.

### *4.2.1. WEED MANAGEMENT*

**Objective:**

> To control and/or eliminate non-native, noxious, and invasive plant species from LNP habitats, and to actively manage for the establishment of a variety of native species and habitat structures within LNP habitats.

The focus of weed management will be integrated to include a suite of treatments depending on site conditions, weed species, and level of infestation. The following is a general list of tools that can be used to combat invasive plants at the LNP (see Appendix C, Noxious and Invasive Integrated Weed Management Plan):

> **Mechanical Treatments**
>
> Mowing, tilling, disking, aerating, haying, or hand-pulling non-native or invasive plant species. Water (flooding or drying) will be used to drown or parch noxious weeds with the goal of creating physiological stress.
>
> **Chemical Treatments**
>
> Use of various herbicide applications that target non-native or invasive plant species in upland and wetland areas. Treatment of wet habitats with chemicals should be minimized and considered only as a last resort. In or adjacent to wetlands, only specific chemicals that are approved for aquatic resources should be used. Integration of other methods in concert with chemical applications will be implemented so that there is not a dependence

on chemical treatment alone, and so that the use of chemicals can be gradually diminished over time.

**Biological Treatments**

Introducing insect herbivores, fungi, or other natural agents that target specific non-native or invasive plant species. The manager should coordinate with APHIS and other neighboring wildlife management areas to maximize benefits from use of bio-control agents. Care must be taken to provide optimal habitat (e.g., host density) and sustenance for bio-control agent nurseries and to prevent predation when possible.

**Grazing**

Use of cattle and/or goats to graze targeted areas, with the goal of containing or reducing populations of invasive plants. Seasonal timing, total grazed area, length of grazing time, and number of livestock must all be considered to maximize impacts on invasive plants and minimize impacts to native plant and animal species.

**Improving Soil Chemistry**

Amending soils in infested upland areas, where salts have accumulated in surface soils and/or organic material is generally lacking from the surface horizon. Use of livestock to add nutrients and work nutrients into surface soils, and potentially light tilling, will be implemented. Note that higher salt concentrations are desired in some habitats, while lower salt concentrations are desired in others. Note also that some wetland areas will be managed to retain and concentrate salts. This strategy can be used to drive succession and suppression of salt-intolerant plants.

**Seeding**

Must be implemented following any of the above treatments. Once invasive species are stressed or removed and the soils are improved, reseeding with native and/or desirable species or planting/transplanting live plants and shrubs will be implemented to cover the ground, until native and/or desirable species become established and have a competitive edge over undesired species. Sterile cultivars can also be used as placeholders during the period it takes native species to become established.

**Establishing a Cooperative Weed Management Area (CWMA)**

Establishing a cooperative team that includes individuals from the LNP "neighborhood" in a community-wide, weed management effort. CWMA participants may agree to collectively employ any of the above treatments, with the goal of cooperatively managing weeds over a greater geographic area.

### *4.2.2. WATER MANAGEMENT*

**Objective:**

To manipulate water and salinity levels of soil and water to benefit desired wildlife and habitat types within the LNP, and to manage water to encourage habitats of particular successional stages.

The following is a list of water management tools to be used at the LNP:

### Artificial Water Development

Installation of artesian wells and utilization of irrigation return flows. Artesian wells will provide a source of freshwater to create and maintain 12 or more acres of slope wetland habitat in areas that do not currently remain wet year-round. Artesian wells can also be installed to enhance the hydrology of existing wetlands on the LNP.

### Inundation

Flooding an area with water. Inundation may be used to kill large stands of invasive plants that do not tolerate flooding. It may provide feeding or nesting habitat particular to specific priority species and may also encourage muskrat activity, which may help to control stands of cattail and phragmites.

### Drawdown

Removing water from an area. This method can cause stress to targeted invasive plant species and can also be used in winter to discourage the presence of carp in LNP waterways.

### Salinity Control

Maintaining salts that favor focal plants and wildlife. Possible treatments include allowing evaporation of water from habitats rather than flushing water out, artificial drawdowns, and adding salts in some areas to maintain saline and hypersaline habitats. Salts present in subsurface soils are drawn to the surface during evaporative processes and crystallize, often forming a crust in areas water completely evaporated. Periodic drawdown of impounded water allows drying and aerating of soils, thereby concentrating salts on the surface and/or within the top few centimeters. This tool can be used to prohibit germination and growth for all but the most salt-tolerant of aquatic and semi-aquatic plant species. This also may be employed as a means to discourage undesirable plant species that are intolerant of elevated salt levels (e.g., phragmites, cattail). Adding salts remains a theoretical treatment, but could be tested in small basins within the LNP as part of an ongoing ecological research project.

### Clarity Control

Managing water clarity and reducing suspended sediment and particulates within waters of the LNP. Treatments may include carp restriction, regulation of water quality from outside sources, reducing fertilizers and other sources of nitrates, discouraging algal bloom, dredging waterways to reduce buildup of sediment and weeds, and planting or seeding native submersed and emergent vegetation to improve water filtration.

### Restriction of Carp

Carp are a non-native species that uproot aquatic vegetation while foraging for food, causing solids to be suspended in the water column and competing with native fish species. Use of drawdowns during winter freeze, combined with infrequent treatments of Rotenone when necessary, should help control carp on the LNP. Drawdowns may also expose carp as a winter food source for Bald Eagles.

#### Wetland Creation

Create wetlands from uplands on other parts of the LNP using a suite of water management tools, including artificial water development. Care should be taken to identify the type of wetlands needed to meet LNP goals, including the ratio of uplands to wetlands, as well as water sources and water rights.

### *4.2.3. PREDATOR MANAGEMENT*

**Objective:**

To reduce predation impacts to populations of preferred wildlife species, particularly priority bird species.

Predator species that are of particular concern at the LNP are classified as unprotected furbearers by UDWR and include red fox, raccoon, striped skunk, and feral cats (UDWR 2006). Native predators are a natural component of the ecosystem; however, if predator populations are high enough to cause declines in the reproductive success of priority and other bird species, predator numbers may need to be reduced. Impacts of predatory mammals on nesting bird species will require regular evaluation to justify their management. If it is determined that lethal control or trap-and-remove practices are necessary to maintain positive rates of nesting success for priority and/or other bird species based on survey data, the population size of predators should be taken into consideration.

Non-native predators such as feral cats can be equally detrimental to wildlife populations, particularly during peak nesting and fledging seasons for ground-nesting birds. To minimize negative impacts to all nesting bird species on the LNP, feral cats should be considered a nuisance and either trapped or lethally controlled when possible, as they are not natural members of the LNP ecosystem.

Timing of predator control is very important. As stated by UDWR, any unprotected fur-bearing species may be taken during daylight hours year round without any required permit or license. Experience at the BRMBR indicates that lethal methods are best implemented from March through July once animals, e.g., foxes, had denned and established their territory. Research shows that new animals will replace exterminated animals at other times of the year because the predator base is so large in the region. Coyotes and avian predators such as ravens, crows, and California gulls may also impact desired wildlife species on the LNP. However, because these avian predators are protected under the Migratory Bird Treaty Act, strategies for control should be coordinated with USFWS.

#### Exclusion and Physical Barriers

Chain-link fence around the exterior of the LNP to discourage encroachment of predators from neighboring residential areas. If deemed necessary, fencing areas with concentrated nesting with mesh and/or electric wire can discourage predators. Installation of moats, water channels, or other barriers along highly populated borders of the LNP may also discourage some predators (e.g., feral or domestic cats).

### Trap-and-remove

Live trapping and relocating of predators. This is labor-intensive, but may be preferred or required for nuisance mammalian species that are not listed by UWDR as unprotected species (e.g., spotted skunk, beaver, mink). Appropriate licensing or permitting may also be required (see Appendix D, Small Mammal Trapping Protocol).

### Lethal Control

Quick-killing traps, live-trapping and shooting, or night-spotlighting and shooting of predators. Lethal control using firearms is the most efficient and cost-effective means of control for predator species. Managers may find it useful to carry a small-caliber firearm (e.g., a .22-caliber rifle) when it is feasible and destroy feral cats when it is safe to do so. Caution should always be taken to be aware of any other persons who may be present on the LNP. Although not required by state law, managers using firearms will carry hunter safety or other legal certification card with them when conducting any lethal predator control. Animals may then be disposed of at remote locations on the LNP. Any night spot-lighting for furbearers requires compliance with UDWR furbearer proclamation laws and regulations (see Appendix D, Small Mammal Trapping Protocol).

### Harassment

While not considered the most effective means of predator control, harassment (e.g., using noise makers to disrupt a colony of gulls) may be an option for reducing impacts to desired wildlife when other, lethal methods are unavailable.

## *4.2.4. GRAZING MANAGEMENT*

**Objective:**

To shift or manage a habitat towards a particular successional stage, and/or to control invasive plant species within a particular habitat or MA.

Grazing can be used to move succession forward or backward depending on the intensity with which it is applied. Consequently it can be more effective in transitioning from short grass to tall grass habitat, and vice versa, than mowing.

### Rotational Grazing

Allowing livestock to remain within a particular area or habitat for a designated amount of time before rotating them out of that area and into a new one. Controlling and minimizing the amount of time a herd of livestock is left to graze an area can affect the level of impact the herd has on a particular plant species, area soils, and other resources.

### Livestock Types

Selecting particular livestock species to manage towards a particular goal. Livestock species can be selected to target a particular invasive or non-native plant species as a food source and employed to reduce or eliminate those plant populations by stressing the targeted plants and preventing them from producing seeds.

### Livestock Concentrations (Number of Head of Livestock)

Manipulating the concentration of livestock in an area to affect the level of impact that the herd has on plant species in the area. Livestock concentration via fencing and provision of water and salt can increase or reduce the amount of time that livestock are required to graze one area to reach the desired effect. Depending on the management objectives, increased livestock concentration, especially goats, can be used to improve soil condition as well as driving desired seed into the soil layer. Water and nutritional supplements may need to be provided to livestock in certain areas while grazing.

## *4.2.5. FIRE MANAGEMENT*

**Objective:**

To maintain or manage a habitat towards a specific successional stage, to control invasive/weed species, to encourage growth of burn-tolerant plant species, and to eliminate or reduce high volumes of fire-fueling plant matter.

Fire can be an important aspect of natural succession within habitats and should be considered for use as a possible management tool at the LNP. Fire management includes actions taken on the LNP to control and contain prescribed fires, as well as actions taken to control wildfires. Prescribed fires can control weeds, remove standing dead vegetation, or modify a specific successional stage.

Any use of fire management requires the proper permitting, training, supervision, and caution, as adjacent neighborhoods and roadways may be affected by controlled burns. Typically, involvement of a land management agency (e.g., Utah Division of Forestry, Fire and State Lands) is recommended for prescribed burns. Such planning and implementation requires equipment, personnel and expertise not currently available at the LNP. A separate document will be necessary to address all the fire management options that are available and feasible for use at the LNP.

### Fire to Manage Weeds

Fire used to effectively control weed species such as tamarisk and phragmites. Use of fire to control weeds at LNP will be conducted in concert with other forms of weed management (e.g., biological control or herbicide application followed by fire to remove dead vegetation), as fire is less effective as a stand-alone management tool. Care must be taken to prevent extermination of desired bio-control agents such as beetles and fungus in burn areas. Restoration efforts must follow any fire management to avoid re-establishment of weeds within a treated area.

### Fire to Manage Succession

Fire used to manage a habitat towards a particular successional stage. At LNP, use of fire may be used to manage grassland or upland brush habitats (e.g., greasewood/alkaline knolls habitat) towards a particular successional stage that benefits priority species. Care must be taken to prevent extermination of desired species. Restoration efforts must follow any fire management to avoid re-establishment of weeds within a treated area.

#### Creation of Fire Breaks

Establishment of fire breaks within the LNP. Fire breaks may help control the spread of wildfires as well as prescribed fires within the MAs.

### *4.2.6. RESTORATION MANAGEMENT*

**Objective:**

To introduce, establish, and encourage the spread or establishment of native or desirable plant and animal species following the removal or extirpation of non-native and invasive species.

Revegetation efforts should follow any active treatment of weeds on the LNP to encourage the establishment of native and desirable plant species, rather than re-establishment of undesirable plant species. Reseeding may be more appropriate following some treatments (e.g., grazing, chemical treatment), while live plantings may be more useful in other cases (e.g., along the Jordan River and State Canal banks to encourage desirable riparian species). Suggested seeding lists are listed in Appendix E, Desired Plant Species.

#### Seeding

Following other management actions in a treated area, spreading seeds of native and desirable plant species towards a particular habitat outcome. Vegetation seed species that are particularly important to focal bird or other animal species may be selected. Seed mixes will be determined based on the preceding and subsequent management actions and soil disturbances and based on habitat objectives (see Appendix E, Desired Plant Species). Seed mixes will vary depending upon the current successional status of the area to be reseeded (i.e., habitats in a lower stage of succession may require that more aggressive, generalist species be established at first to compete with weed species). A variety of reseeding methods may be used, including broadcast seeding, disking, or other methods deemed appropriate depending on soil type and preparation.

#### Planting

Planting live plants by hand or other mechanical means (tractor, farm equipment) to establish native plant species after other management treatments. This method will be used in cases where seeding is not effective, where quicker plant establishment is desired to out-compete non-native species, or where varied plant developmental stages provide high-quality habitat (see Appendix E, Desired Plant Species).

## 4.3. COMBINED TOOLS FOR BETTER MANAGEMENT

While all the tools listed in this document are effective in helping to manage habitats at LNP, the same tools can become exponentially more effective when used in combination with one another. Managers at LNP should consider the possibility of using two or more tools in tandem when making management decisions.

For example, relying strictly on biological controls may be effective alone, but may also take many seasons before control of weeds is achieved. However, if biological controls on a weedy species are combined with another tool such as grazing, a weedy species can be stressed in a

concentrated fashion, and control may be achieved over a much shorter period of time. It is recommended that LNP managers use creativity in combination with good judgment to combine management tools, and manage habitats in new and innovative ways to improve the biological integrity of the LNP. Keeping up to date with new research and new technologies may also provide new tools to be added to this chapter at any time.

Other management ideas for potential management strategies to benefit habitats and wildlife at LNP include installation artificial nest boxes, nest platforms, and nest islands to encourage breeding of priority and other bird species. Improvements such as nest boxes will be addressed in more detail in future revisions of the HMP, after habitat improvements are addressed and under way. Many options may be investigated regarding type and placement of nest boxes to attract desired bird species to the LNP. Organizations such as Boy Scouts of America can often be an asset in volunteer time and effort to build and place boxes. Volunteer and volunteer organizations can be approached once LNP managers and committee members decide upon what species are in need of additional nest sites on the LNP.

# CHAPTER 5. MANAGEMENT AREA (MA) PRESCRIPTIONS

Each MA within the LNP contains unique habitats and features that require consideration to devise a comprehensive list of management prescription options. The purpose of this chapter is to provide management direction for each MA at the LNP by identifying major management goals and objectives, followed by treatment options for each. During the first year of implementation, monitoring of existing hydrological modifications will be integral to managing for specific habitats through water manipulations and may result in changes to the management objectives. As they are written now, water related prescriptions address specific habitat requirements with existing control structures and knowledge of topography. Additional and deliberate observation of the ground and surface waters during the early spring through early summer will be necessary to understand how the floodplain operates with inundation from Jordan River over-bank flows and precipitation. More detail on monitoring is given in Chapter 6, however it is mentioned at this time because managers will use the information gained from the monitoring to adapt their management actions to achieve desired effects. The same holds true for other management actions (e.g., weed control), but the time scale is different. That is, results from weed control efforts may not be evident until the following year when decisions to maintain the same management strategy versus making adjustments can be made. This chapter consists of the resulting list of management prescriptions categorized by MA for the LNP. An annual review of management practices at the LNP may necessitate altering the objectives and/or adjusting the use of prescriptions as new issues or techniques arise.

## 5.1. RIVERINE MA

Water management is one major management tool to be used in the Riverine MA, as it will help to restore and mimic historic processes related to habitat types of an active floodplain. The Riverine MA contains lentic and lotic freshwater ecosystems. The three dominant water features are the North Canyon Meander, Sorensen Slough, and Jordan River. Some water control structures were installed to maintain desired water levels in historic river meanders within the Riverine MA. These control structures will allow managers at LNP to manipulate the amount of water added to the system. This will be an asset from year to year and even from day to day, as the amounts of natural water from sources such as snowmelt, runoff, and flooding may vary greatly from year to year. All management activities within the Riverine MA must comply with federal buffer zone requirements around the Bald Eagle nesting platform. Minimal access to water features may be required during designated eagle buffer periods and agreements should be made with the USFWS and UDWR regarding access to structures during times when no eggs or young are present (see Appendix B. Eagle Nest Restrictions, for guidelines).

### Goal

Maintain a seasonally inundated freshwater wetland habitat mimicking an active floodplain with adjacent uplands that will provide a range of water depths and vegetative structure for foraging waterbirds and riparian species.

### Objectives

- Seasonally inundate the MA to a water depths of more than 12 inches within the North Canyon Meander and Sorensen Slough until July 1.

- Seasonally inundate lands adjacent to North Canyon Meander and Sorensen Slough with water at variable depths—0 to 6 inches and 6 to 12 inches—to create feeding habitat for priority bird species.
- Increase riparian tree and shrub cover to 25% along Sorenson Slough, North Canyon Meander Channel, and Jordan River by 2011.
- Maintain water quality in North Canyon Meander and Sorensen Slough as prescribed by the Utah Department of Water Quality for beneficial use 3D.[2]
- Decrease hoary cress cover to less than 20% by the end of 2011.
- Prevent invasion by purple loosestrife and keep cover at less than 1% .
- Decrease tamarisk to less than 1% by the end of 2009.

### Strategies

- Apply integrated weed management using biological, mechanical, and chemical controls, minimizing herbicide/pesticide application.
- Deliver water via the North Canyon Meander or Jordan River in conjunction with water control structures to achieve desired inundation depth, duration and area.
- Conduct periodic drawdowns within the MA to control carp as needed.
- Limit the use of Jordan River water for inundation for water quality reasons.
- Reestablish riparian habitat structure and diversity using native or desired tree and shrub species in patches along the waterways.

### Desired Habitat

Fresh, deepwater habitat, riparian, wet meadow and emergent freshwater marsh along watercourses.

### Other Habitat

Upland grass and forb communities.

### Prescriptions

- The Riverine MA will provide a mid-successional plant stage dominated by bulrushes and tall wet meadow species. The focal weeds in the MA are hoary cress, perennial pepperweed, tamarisk, Russian knapweed and purple loosestrife.
- Chemical treatment should be restricted in the western portions of the MA, along the Jordan River and the historic meanders that will be inundated with water using the installed hydrological structures. However, the presence of knapweed along the Jordan River may necessitate the use of herbicides.
- Spot-treat tamarisk mechanically for control of smaller, isolated infestations. In areas where small populations of tamarisk are establishing, it may be more efficient to cut down shrubs with a chainsaw or loppers and treat the stumps with an herbicide to eliminate regrowth. Alternatively, the trees can be girdled, sprayed with Garlon, and left as perches for birds.

[2] Protected for waterfowl, shore birds and other water-oriented wildlife not included in Classes 3A, 3B, or 3C, including the necessary aquatic organisms in their food chain (CWA, Section 303[d]).

- Apply goat grazing on a rotational basis throughout the growing season. Goats have already been introduced in this MA. Documenting the effects of grazing is needed in order to effectively implement this prescription.
- Apply biological treatments available for tamarisk (i.e., *Diorhabda elongata*, a tamarisk leaf-eating beetle and *Trabutina mannipara*, a mealy bug) and purple loosestrife (i.e., mainly *Galerucella* spp., a leaf-eating beetle). However, it is unknown at this time if this MA contains a stand of tamarisk with the density necessary to support the leaf-eating beetle. Consider combining biological controls with other treatments.
- Apply water from the North Canyon Canal to inundate portions of the MA to the desired depth. Under current conditions, water overflows the meander banks out into the floodplain. While there are stop logs at the outlet to the Jordan River, channel depth does not rise high enough to overflow at the lowest setting. After monitoring the extent of the inundation from over-bank flow, the amount of flow can be adjusted to reach desired effect.
- Modify the outlet structure to allow water to exit the meander channel into the Jordan River if flushing is determined to be a management prescription.
- Apply only enough water to the MA to offset evapotranspiration losses in order to maintain soil salinity and once desired and dynamic water levels are achieved.

## 5.2. EVAPORATIVE BASINS MA

Long-term loss of salts from the Evaporative Basins MA appears to be causing a shift from a salt-tolerant plant community to a mixture of salt-tolerant and salt-intolerant species with increased vegetative coverage in the basins as observed during baseline years. Management that impedes this process will maintain diverse salt-controlled habitat types. The effectiveness of water conveyance into and throughout the Evaporative Basins MA will need to be tested and perhaps modified as detailed in the CWMP. It is recommended that any topographic modifications to the area be kept to a minimum, as this portion of the floodplain is discrete in area, and surface disturbance may result in increased invasive plant infestation.

### Goal

Maintain a seasonally inundated salt meadow with adjacent riparian zones along the Jordan River and brackish marsh habitat.

### Objectives

- Utilize surface water diversions to inundate the Evaporative Basins MA during early spring to more than 12 inches during the nesting season (to July 1).
- Drawdown after July 1 to less than 12 inches to create feeding habitat.
- Control water levels in evaporative basins to decrease flow-through and concentrate salts.
- Increase riparian tree and shrub cover to 25% along Jordan River by 2011.
- Maintain soil electrical conductivity at 8.60 dS in the evaporative basins (Keate 2005).
- Supply water to sustain a brackish permanent emergent marsh.
- Decrease hoary cress cover to less than 20% by the end of 2011.
- Decrease phragmites cover to less than 10% by the end of 2009.

- Decrease tamarisk and Russian olive cover by 50% by 2009.
- Decrease bull thistle cover to less than 20% by end of 2011.
- Restrict cover of small populations of perennial pepperweed, purple loosestrife, musk thistle, and Dalmatian toadflax to less than 1% by the end of 2011.
- Maintain water quality as prescribed by the Utah Department of Water Quality for beneficial use 3D.

### Strategies

- Apply integrated weed management using biological, mechanical, and chemical control, minimizing herbicide/pesticide application.
- Deliver water via the North Canyon Meander or Jordan River through the Riverine MA, in conjunction with Kim's Junction water control structure, to achieve desired inundation depth and location.
- Concentrate salts in evaporative basins using evaporation of groundwater and surface water as a tool.
- Revegetate the banks of the Jordan River with patches of native or desired tree and shrub species and increase coverage of desirable grasses.
- Maintain a permanent water regime (standing water continuously present in all years) in the brackish emergent marsh.
- Maintain state canal berm and Jordan River levee to keep water from emergent marsh area from draining.

### Desired Habitat

Seasonally flooded salt meadow interspersed with evaporative basins.

### Other Habitat

Riparian, emergent, and brackish marsh along watercourses.

### Prescriptions

- Limit the use of chemicals and large machinery to control weeds, as soils commonly remain wet in this MA year-round. Hoary cress, thistle, perennial pepperweed, and teasel are the dominant weeds within this MA.
- Apply grazing as a weed management technique during the growing season. Goats have already been applied to the Evaporative Basins MA to help control phragmites, hoary cress, perennial pepperweed, and other noxious and undesirable plant species. Early and repeated grazing of thistle species before they go to seed can stress plants and control their spread.
- Apply mechanical treatment to the small infestations of tamarisk in this MA. In areas where tamarisk is established, it may be efficient to cut down shrubs with a chainsaw or loppers and treat the stumps with an herbicide to eliminate regrowth. Mechanical control of tamarisk will be useful in combination with grazing of goats. Tamarisk populations may not be large enough to support biological control; however, efforts to introduce tamarisk leaf-eating beetles is underway at neighboring preserves and, if successful, will eventually help control tamarisk at the LNP.

- Apply biological controls to purple loosestrife established on the western edge of this MA, along the Jordan River. Biological controls for purple loosestrife (mainly *Galerucella* spp., a leaf-eating beetle) can be obtained from USDA APHIS or from insect populations that have already been established at neighboring preserves. USDA APHIS can provide up-to-date information on the nearest places to collect biological control insects in the region and how to introduce them. Coordination with mosquito abatement pesticide application may minimize loss of purchased insects.
- Apply inundation and drawdown strategies to elevate salts. Continuous flow-through is not an option, as salts will be lost from the system. Instead, water—whether sourced from subsurface sediments, transported into the wetlands as dissolved mineral salts, or artificially added to the water—should evaporate and concentrate salts.
- Monitor inundation depth to avoid flooding active nests. Artificial drawdown may be necessary during seasons with heavy precipitation, high snowmelt, and runoff to maintain standing water below the edges of the basins. Infrastructure of water conveyance is detailed in the CWMP.
- Allow natural drawdown to concentrate salts in the MA and provide a continuous supply of macroinvertebrate food base for shorebirds along dynamic shorelines. Shallow basins of 6 inches of water or less can be highly productive if water and soil chemistry allow.
- Research salt augmentation as a strategy for reducing vegetative cover and restoring playa-like habitat for shorebird use in evaporative basins. The most practical method and amount of salt application will need to be determined, but may be implemented to reset succession in the basins.

## 5.3. ALKALINE FLATS & SLOPE WETLANDS MA

The Alkaline Flats & Slope Wetlands MA is currently a mosaic of alkaline uplands and depressional wetlands with a shrub/scrub component and associated grasslands. It provides a sizeable upland buffer between the Legacy Parkway and Jordan River floodplain wetlands. Based on the MA's potential relative to soil characteristics, the focus of management activities should be restoring native or desirable plant communities. Embedded within this MA will be 12 acres of slope wetlands, per the USACE Section 404 permit conditions.

### Upland Goal

Maintain climax plant communities of grassland and alkaline knolls habitats that provide diverse conditions for upland bird species and provide a buffer for wetlands in the Riverine MA and Evaporative Basins MA.

### Slope Wetland Goal

Create 12 acres of slope wetlands within the larger upland habitat under the conditions specified in the Section 404 permit.

### Upland Objectives

- Re-establish desirable grass species by seeding 25% of the upland portion of the Alkaline Flats & Slope Wetlands MA as part of integrated weed management by 2009.
- Decrease hoary cress cover to less than 20% by the end of 2011.

- Decrease perennial pepperweed cover to less than 20% by the end of 2009.
- Decrease intermediate wheatgrass cover to less than 20% by the end of 2009.
- Reclaim 90% of existing roads and ditches.
- Increase native or desired grasses by 20% by 2010.

### Upland Strategies

- Integrated weed management using biological, mechanical, and chemical controls. Graze 20% of this MA as part of an integrated weed management program by 2010. Use mechanical methods on 5% of the upland portion to introduce a controlled disturbance, followed by seeding.
- Fill ditches that serve as hydrologic modifications or weed vectors.
- Regrade existing roads to match surrounding contours where they are not needed for management activities.
- Reseed grasslands with native or desired species to provide competition for non-native or invasive species as a component of weed management.

### Slope Wetland Objectives

- Meet the less-than-20% non-native species cover success criteria outlined in the ROD by the USACE.
- Maintain 12 acres of slope wetlands.
- Provide shallow water (0–6 inches) and mid-depth water (6–12 inches) habitat for priority bird species feeding and nesting habitat.
- Maintain water quality as prescribed by the Utah Department of Water Quality for beneficial use 3D.

### Slope Wetland Strategies

- Apply integrated weed management using biological, mechanical, and chemical control, minimizing herbicide/pesticide application.
- Manipulate artesian well flow rates and dispersal areas to maintain 12 acres of wetted area capable of supporting hydrophytic vegetation under current topographic conditions.
- Revegetate using native or desired wet meadow and emergent marsh species, depending on water depth as a function of existing topography.

### Desired Habitat

Wet meadow (slope wetland), alkaline knolls (upland) and unvegetated flats (upland).

### Other Habitat

Upland grassland (upland).

### Prescriptions

- Integrate multiple treatment methods for control and eradication of hoary cress, perennial pepperweed, teasel, phragmites, and cheatgrass, which are established in large areas of this MA. Minimize chemical applications in created slope wetlands (see Appendix C, Noxious and Invasive Weed Management Plan).
- Apply grazing during the growing season and at other times as dictated by weed ecology and physiology. Closely monitored and properly managed rotational grazing of grassland

habitat by goats, sheep and/or cattle can be used to control weeds as well as maintain short grass habitat structure, favorable to Long-billed Curlew and Burrowing Owl. Early grazing on the annual cheatgrass, with simultaneous seeding with desired species, may enable a shift in grass community towards desired shortgrass species. In this case, grazing may be used as a disturbance vector and mechanism to purposely shift a plant community that is dominated by an introduced, annual, invasive species to a more complex assemblage of annual and perennial native or naturalized species. The timing, frequency, and duration of grazing will be implemented with careful consideration of its efficacy for each target species. Goats/Cattle will be kept out of prime nesting habitat during late May through June in shortgrass habitat. Care must be taken to prevent goats and cattle from disturbing the alkaline flats.

- Inundate using flow from artesian wells to create at least 12 acres of slope wetlands. If full volume and flow from artesian wells proves to create management issues such as erosion, channelization, or monotypic stands of cattail, moderate flow to a level that sheetflows at slow velocities. Carex species are sensitive to high water velocities and sedimentation and can be used as an indicator of appropriate flow. If the extent of aerial coverage flow from the spreaders does not provide 12 acres of saturated soil conditions, spreaders may be readjusted to take better advantage of existing topography. The amount of relocation will be limited to the design of the spreaders (see the CWMP for more detail). If the proposed artesian wells do not produce enough flow, or the soil lacks the characteristics to create 12 acres of slope wetland, drilling an additional well may be necessary to comply with the Section 404 permit. Additional well sites are detailed in the CWMP.

## 5.4. WET MEADOW MA

Wetlands currently present on the Wet Meadow MA are sustained by irrigation return flow from adjoining properties. Local soil characteristics and available water rights indicate that maintenance of existing wetlands and creation of new wet meadows are possible within this MA. Included in this MA is the 125-acre Parcel, which is identified as the most suitable access and education point for the public visiting the LNP. Development of locations for interpretation is regulated by conditions outlined in the Section 404 permit.

### Goal

Maintain a wet meadow and upland mosaic that will provide diverse plant communities for foraging and nesting bird species and will provide fresh water supplies for migratory shorebirds.

### Objectives

- Decrease hoary cress cover to less than 20% by the end of 2011.
- Exclude other noxious and invasive weed species from infesting the MA (less than 5% cover).
- Maintain sheetflow (less than 6 inches) across currently wet areas with supplemental irrigation water.
- Create 10 acres of additional wet meadow with supplemental irrigation water or artesian wells at a depth of 0–6 inches.

- Exclude freshwater from evaporative basins on the west side of the MA through control of water source.

### Strategies

- Apply integrated weed management using biological, mechanicals and chemical controls, minimizing pesticide/herbicide application.
- Develop available irrigation water to sustain existing and future wet meadow communities within the MA.
- Provide additional surface water for wet meadow creation using artesian wells.
- Revegetate using native or desired freshwater wet meadow species.

### Desired Habitat

Freshwater wet meadow.

### Other Habitat

Upland grassland and evaporative basins.

### Prescriptions

- Apply weed treatment(s) to control and reduce hoary cress, teasel, perennial pepperweed, phragmites, and tamarisk in this MA. Large portions of this MA are relatively weed free. Care must be taken to recognize current weed vectors and not establish new weed vectors through this area, and to curtail the advance of weeds from other areas, specifically the Alkaline Flats & Slope Wetlands MA.
- Apply goat grazing to phragmites in the Wet Meadow MA. Hoary cress and other weedy species may be treated with goat grazing if started in late winter or early spring.
- Inundate using unobstructed water flow from supplemental irrigation and/or artesian wells to restore and maintain wet meadow hydrology. If flow proves to create management issues such as erosion, channelization, or monotypic stands of cattail, flow will be moderated to a level that provides for sheetflow at slower velocities. Carex species are sensitive to high water velocities and sedimentation and can be used as an indicator of appropriate flow.
- Relocate spreaders if the aerial coverage of flow from the spreaders does not provide adequate soil saturation. Spreaders may be readjusted to take better advantage of existing topography. The amount of relocation will be limited to the design of the spreaders (see the CWMP for more detail).
- Develop an additional artesian well if the proposed artesian wells do not produce enough flow to inundate wet meadow areas. Drilling an additional well will be necessary to comply with the Section 404 permit. Additional well sites are detailed in the CWMP.

## 5.5. FARMINGTON BAY MA

This MA's proximity to the Farmington Bay Waterfowl Management Area necessitates coordination of management strategies in these two entities, especially regarding weed control and water. The Farmington Bay MA is primarily an emergent marsh with occasional evaporative basins and uplands. While not unique to this MA, illegal access (trespassing) is an issue, as

evidenced by the disturbance that vehicles have caused (and continue to cause) to soil and plant communities.

### Goal

Maintain a wetland/upland transition zone that serves as a buffer between development and the Farmington Bay Waterfowl Management Area.

### Objectives

- Seasonally inundate the MA in coordination with Farmington Bay Waterfowl Management Area.
- Decrease phragmites cover to less than 20% by the end of 2010.
- Restrict the establishment of new invasive or noxious weed species.

### Strategies

- Restrict soil and/or vegetation community disturbance caused by vehicles.
- Apply integrated weed management using biological, mechanical, and chemical controls, minimizing pesticide/herbicide applications.
- Deliver water as a component of integrated weed management via the Farmington Bay Waterfowl Management Area, to a depth and duration that does not facilitate the spread of noxious or invasive weeds.

### Desired Habitat

Freshwater emergent marsh 1–15 inches deep, evaporative basins and uplands (shrubs and grassland).

### Other Habitat

Upland grassland.

### Prescription

- Apply weed treatment(s) to control and eradicate hoary cress, phragmites, teasel, perennial pepperweed, tamarisk, and Dyer's woad, which are the dominant weeds within this MA. To-date goat grazing has targeted phragmites within this MA, though hoary cress and other weedy species may be managed using goats if grazing is started in late winter or early spring.
- Coordinate water management (timing, duration and depth) with UDWR personnel, as the primary source of water to this MA is the Farmington Bay Waterfowl Management Area.

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# CHAPTER 6. MAINTENANCE, MONITORING, AND ADAPTIVE MANAGEMENT

## 6.1. MAINTENANCE

Maintenance activities will be required continuously to maintain equipment, preserve boundaries, maintain habitats, and support the species diversity indefinitely. Maintenance activities will be ongoing once management practices are established. Common and expected maintenance activities for the LNP include:

- Maintenance of Equipment – Chemical spray equipment (ATVs, backpack sprayers, tractors), mowing equipment, brush clearing machinery (chainsaws, brush-wackers, etc), firearms, traps, and all vehicles. Keep trucks, ATVs, and tractors tuned up and serviced. Keep all firearms cleaned and in good working order. Store firearms and ammunition appropriately and safely in a locked storage compartment/locker. Keep all chemical sprayers, brush equipment, machinery and traps washed and cleaned prior to storage. Avoid transfer of noxious weed parts or seeds from one area to another on equipment.
- Maintenance of Chemicals – Keep all chemicals as instructed by the labels on bottles, jugs, and boxes. Keep cool and dry. Keep organized and well labeled (if not in original container) so none are misidentified. Note that if using registered herbicides, applicator must have a current herbicide application license and labels on hand while applying chemicals. Maintain a spill cleanup kit. Wear appropriate clothing and eye/skin protection while handling all chemicals.
- Maintenance of Fences and Roads – Maintain all boundary fences in good condition and mend when needed or contract out for repairs. Make sure all signage is in good shape and legible. Replace stolen or vandalized signs as needed. Keep gate locks cleaned and in working order and replace when necessary. Contact UDOT to regrade LNP roads and fill potholes when necessary.
- Maintenance of Water Structures – Clear passageways of debris and add or remove stop logs of water control structures to retain or release water as detailed in the CWMP. Turn conveyances and well heads on or off to achieve the desired amount of flow within each habitat and/or MA. Repair damage to berms and dikes from burrowing animals.

## 6.2. MONITORING AND SUCCESS CRITERIA

The Record of Decision (ROD) for the Legacy Parkway issued by the USACE (2005) requires that annual monitoring be conducted until the success criteria for each Management Area have been met for 3 consecutive years. The overarching success criteria established in the ROD are twofold:

1. that a minimum acreage of wetland-wildlife habitat within each MA (including 12 created slope wetland acres) is maintained in good condition, per Table 6.1; and
2. that relative cover of noxious/invasive weeds in each plant community does not exceed 20% (plant community being equivalent to habitat classes presented in Chapter 2 of this document).

**Table 6.1. Wetland Complex/Riparian Habitat Acreage Success Criteria, by MA**

| MA | Acres |
|---|---|
| Riverine MA | 63 |
| Evaporative Basins MA | 193 |
| Alkaline Flats & Slope Wetlands MA | 137 (+12) |
| Wet Meadow MA | 138 |
| Farmington Bay MA | 363 |

The ROD further requires that "quantitative success criteria, with proposed survey methods, used to monitor characteristic vegetation and hydrology and measure success" be developed. Originally slated for the draft Mitigation Plan in 2006, development of these quantitative success criteria was deferred to this and other resource management plans, since the goals for habitat and water management at the LNP had not yet been fleshed out. The HMP addresses habitat specific criteria, while the CWMP addresses criteria for water resource management.

Baseline data are necessary to provide a statistical benchmark to compare against subsequent, post-mitigation survey data. Most of the baseline data gathered for the LNP has already been summarized (SWCA 2006a, 2006b, 2006c, 2006d). As the LNP system gains ecological function and as habitat condition improves, post-mitigation survey data will be proven significantly different from or comparable to baseline data by means of simple regression analysis, depending on the criterion.

Seven different survey protocols are currently being implemented at the LNP. These were originally employed for gathering baseline data and now serve as ongoing monitoring protocols:

1. Vegetative species composition transects a) through the Jordan River Floodplain and b) across evaporative basins.
2. Relevé plots within alkaline flats.
3. Species composition transects in several areas of the LNP to monitor the effect of noxious and invasive plant control measures.
4. Vegetative species composition transects to monitor the development of created and restored slope wetlands from artesian well flows.
5. Vegetative mapping of a) habitat type and b) noxious and invasive weeds.
6. Bird surveys.
7. Small mammal surveys.

The following sections describe the methods for each monitoring protocol. Monitoring data and descriptive information will help identify whether a prescribed habitat is responding to the applied hydrologic regime or other management practices. Metrics used, and success criteria for monitoring and measuring success are listed at the end of the monitoring protocol descriptions.

### *6.2.1. Jordan River Floodplain Transects*

The Jordan River floodplain is transversed by six transects that perpendicular to the river, starting at the streambank and extending eastward until they reach upland topography (see

Appendix G, Monitoring Waypoints). The length of these transects varies, the shortest being 480 m and the longest being 700 m. These transects occur in the Evaporative Basins and Riverine MAs and extend slightly into the Alkaline Flats & Slope Wetlands MA.

Square meter quadrats are taken every 20 m along the transect, starting at meter zero (Figure 6.1). In these quadrats, two sets of data are gathered: ocular percent cover of all species, and average height of the dominant species. Soil moisture conditions are also noted, as are specific topographical conditions and the presence of any standing water. Photos facing all cardinal directions are taken at the beginning, end, and 250-m mark of each transect.

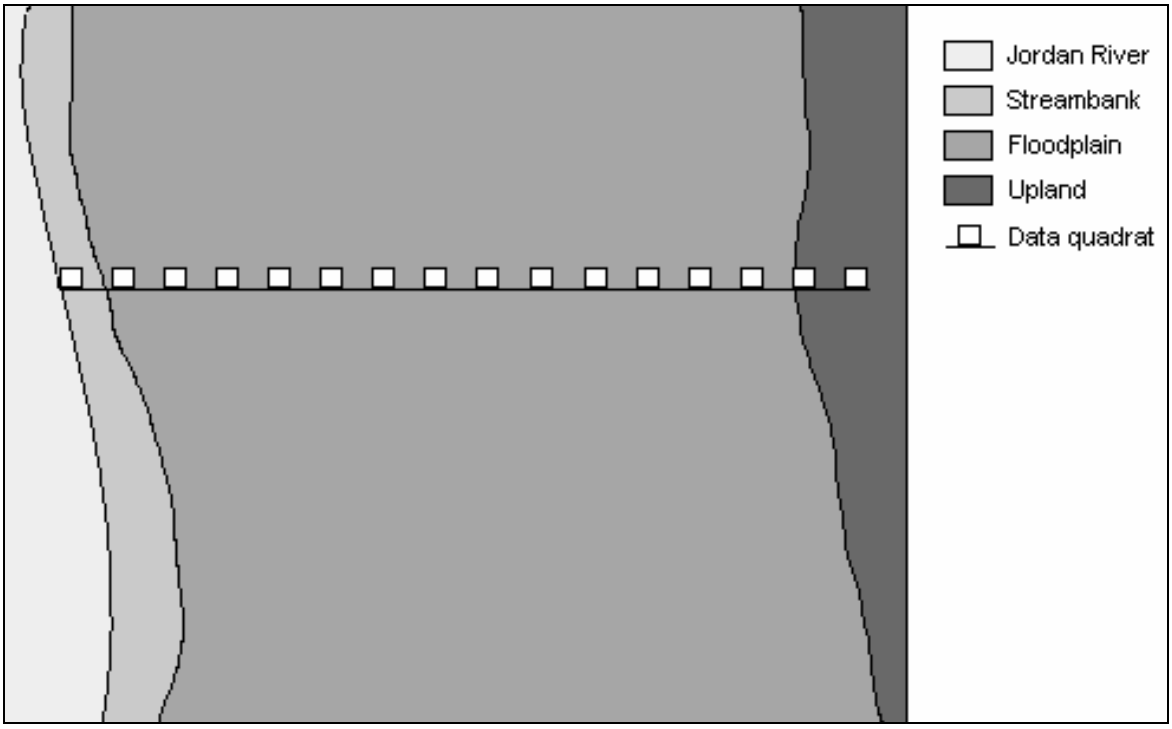


**Figure 6.1. Diagram of the placement of Jordan River Floodplain transects and their associated data collection quadrats.**

*Transects cut through riparian, salt-affected floodplain, and grassland habitat. Quadrats are assessed every 20 m along the transects.*

Pre-mitigation baseline data for these transects were gathered in 1999, 2000, and 2001. Post-mitigation monitoring commenced in 2005. Because of time constraints due to nesting Bald Eagles in the area, the window for walking these transects is between August 1 and November 1, although it is best to do them in early in August when the plants are still identifiable. It is also important that this survey is conducted after all vegetation has completed its growth, in order to get the most accurate information on cover and height.

### *6.2.2. Evaporative Basin Transects*

Data on the vegetation characteristics of the 6 evaporative basins in the Jordan River floodplain have been collected since 2001. The lengths of these transects differ depending on the 2001 width of the basin, ranging from 48 to 106 m long. All of the evaporative basins that are studied

under this method occur within the Evaporative Basins MA. Start and end points of the basin transects are listed in Appendix G, Monitoring Waypoints.

Each transect starts and ends 6 m beyond the boundary of the basin as it was determined in 2001. Sampling of the interiors of the basins occurs at 5-m intervals along the transect lines, and sampling of the edges occurs at 1-m intervals along the transect lines, between the current boundary of the basin and the start or end point (see Figure 6.2), in order to detect subtle changes in edge vegetation. In cases where the edges of the basins are not a distinct boundary between bare ground and wet meadow or upland vegetation, the edges are defined as the point where pickleweed or barren ground exceeds 50% of total cover. Some species that grow in saline depressional wetlands (e.g., pickleweed, *Salicornia rubra*, and seepweed, *Suaeda calceoliformis*) actually help define the extent of the basins based on their known tolerances to salt and alkalinity (see Appendix F, Playa Vegetation).

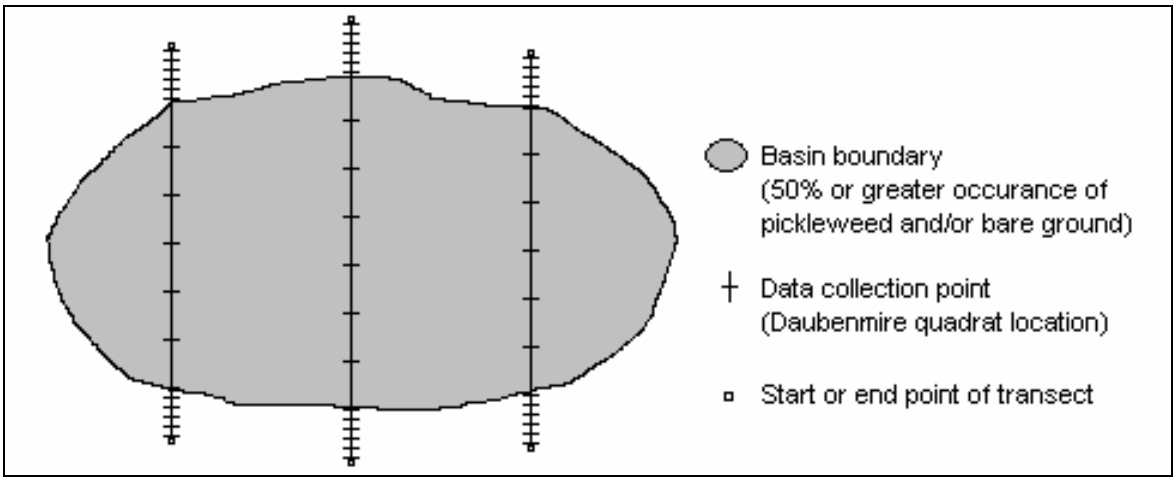


**Figure 6.2. Evaporative basin transect layout.**

*Each studied basin is crossed by three transects. Data is collected at 1-m intervals when the transect line occurs outside the boundary of the basin, and at 5-m intervals when the transect is within the basin. The boundary of the basin is defined as where the vegetation changes from wet meadow species (e.g., Distichlis spicata, saltgrass) to 50% or greater playa vegetation (usually pickleweed) and/or bare ground.*

Percent cover of vegetation species are determined by visually estimating cover using a Daubenmire quadrat, which is 20 × 50 cm (inside dimension) and painted to divide the frame into reference areas of 1%, 5%, 10%, 30% 25%, and 50%. Average maximum canopy height is determined by measuring the standing height of the three tallest individual plants within each quadrat.

Photos are taken in each cardinal direction at the start and end of each transect. GPS waypoints are used to relocate the permanent start and end points of each transect, and the boundaries of the playa vegetation are outlined using GPS for use in change detection analysis.

Pre-mitigation baseline data for these transects were gathered in 1999, 2000, and 2001. Post-mitigation monitoring commenced in 2005. These transects should be walked in the late summer or early fall, when conditions have become drier and vegetation has reached its maximum height and cover.

In cases where the current boundary of the basin is dramatically different from the 2001 boundaries, it is necessary to alter the data collection intervals. Data are still collected every 1 m for 6 m at the beginning and end of each transect, but the interval may need to transition to every 5 m, even when there is no sign of a change in vegetation types (see Figure 6.3).

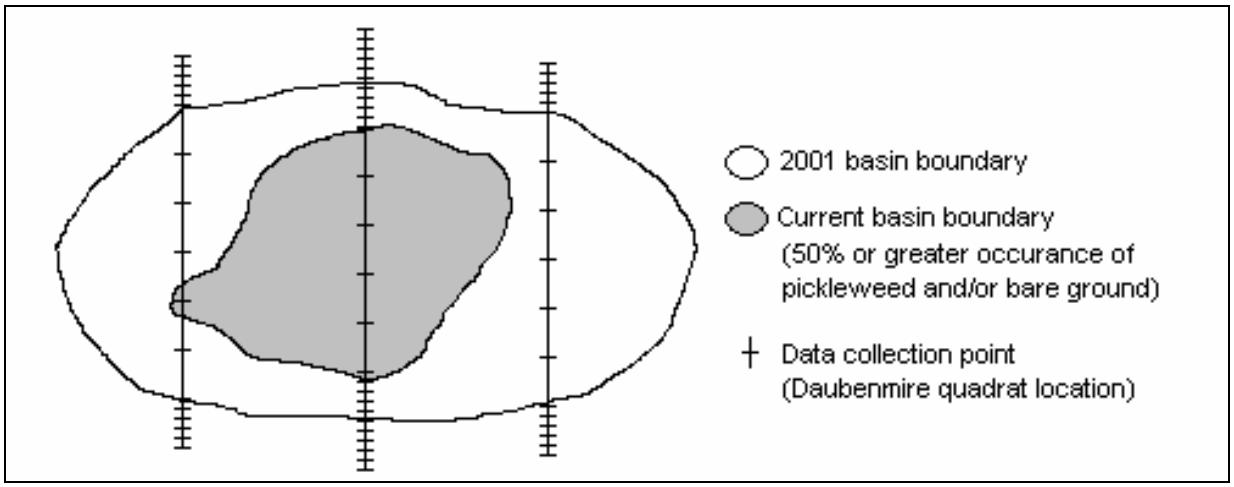


**Figure 6.3. Alternate quadrat interval strategy to be used when evaporative basins have changed so that more area is occupied by wet meadow species and less area is occupied by playa species and/or bare ground.**

*Six quadrats are still done at each end of the transect, but interval changes to every 5 m after that even though vegetation has not indicated the boundary of a playa. If the basin has only shifted by a few meters, as in the center transect shown, quadrats are done every meter until the new edge of the basin.*

If the boundary of the basin only differs by a few meters (1 to 5 m) in either direction from the 2001 boundaries, quadrats should still be done every meter. This may mean that quadrats are taken at 1-m intervals for as little as 1 m if the basin boundary has expanded, or as many as 11 m if it has contracted. In general, the rule is to do quadrats at 1-m intervals until the edge of the playa vegetation if possible. If this is impractical, it is permissible to change to 5-m intervals after the initial 6 quadrats are done at 1-m intervals.

Data collected for these evaporative basins is analyzed yearly to determine the following:

- change in basin size based on GPS data,
- change in percent of vegetation cover for the entire basin,
- change in total number of species (species diversity),
- change in the relative compositions of vegetation species occurring within the basin,
- occurrence of introduced, noxious, or non-native species,
- occurrence of non-wetland species based on indicator statuses, and
- change in average canopy heights.

### *6.2.3. Alkaline Flat Relevé Plots*

Data from relevé plots in six alkaline flats in the Alkaline Flats & Slope Wetlands MA have been collected since 1999 using the Braun-Blanquet relevé technique (Braun-Blanquet 1928, 1951) as

described below. All of the alkaline flats that are studied under this method occur within the Alkaline Flats & Slope Wetlands MA (see Appendix G, Monitoring Waypoints).

Circular plots are laid out in each of the six flats. Each plot has a radius of 10 m (marked by a meter tape), making the total area about 314 m² (Figure 6.4).

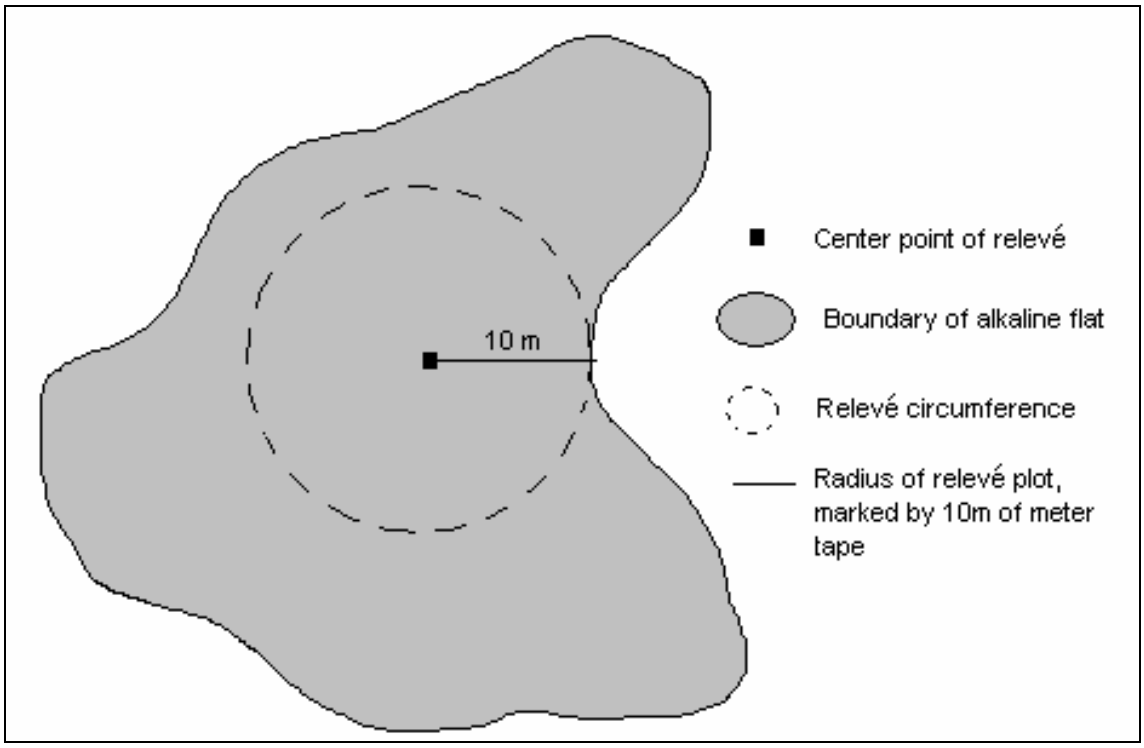


**Figure 6.4. Relevé layout within an alkaline flat.**
*A meter tape extends from the center of the relevé to 10 m outward toward the nearest edge of the flat.*

The entire relevé area is visually assessed, the percent covers of all vegetation species are approximated, and three maximum heights are taken for each species. General sketches of the relevé plot and a representation of the species that occur along the transect line are drawn on the data sheet (Figure 6.5).

General observations of soil characteristics are recorded, including the presence or absence of salt or biotic crusts and the moisture content at all relevé plots. Photos facing into the relevé plot are taken from each end of the meter tape. The outline of the entire flat is recorded with a GPS device in order to detect changes in area from year to year.

Pre-mitigation baseline data for the relevé plots were gathered in 1999, 2000, and 2001. Post-mitigation monitoring commenced in 2005. These plots are usually done in late summer or early fall, after vegetation has had a chance to reach its full size and range.

Data collected from the relevé plots is used to show changes in the following:

- total vegetation cover,
- total number of species (diversity),
- species composition,

- average canopy height,
- presence of non-native, invasive, and noxious species,
- occurrence of non-wetland plant species, and
- boundaries of alkaline flats based on GPS data.

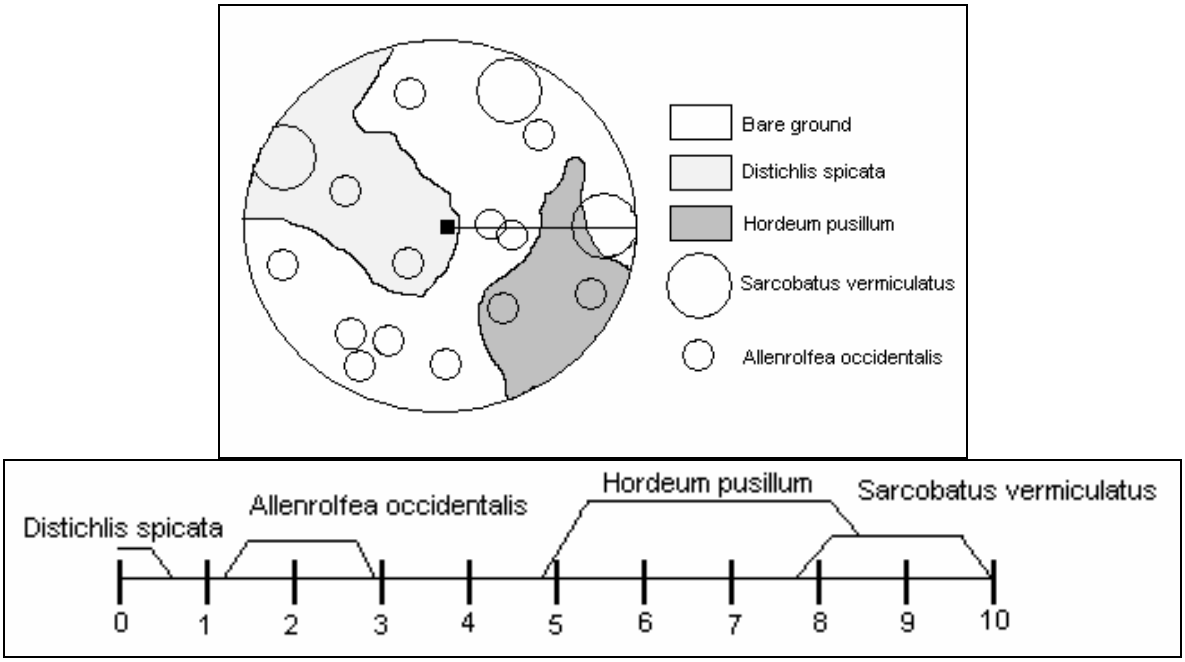


**Figure 6.5. Example of plant species occurrence sketch for a relevé plot and for a 10-m relevé plot radius.**

### *6.2.4. NOXIOUS AND INVASIVE WEED TRANSECTS*

Transects through areas infested with noxious and invasive weeds were established in summer 2006, in conjunction with the first year of herbicide application and large-scale grazing by goats on the LNP. The purpose of these transects is to monitor an area that has been treated with herbicide or biological control and to determine whether the control effort is effective.

These transects are placed so that the responses of different vegetation communities and habitat types can be studied (see Appendix G, Monitoring Waypoints). There are two transects in the Wet Meadow MA (freshwater marsh habitat), one in the Farmington Bay MA (alkaline knolls habitat), one in the Alkaline Flats & Slope Wetlands MA (grassland habitat), and three in the Evaporative Basins MA (one in riparian habitat, two in phragmites-colonized freshwater marsh habitat).

The length of the transects in the Farmington Bay MA, Wet Meadow MA, Jordan River riparian habitat, and grassland habitat are each 50 m long with quadrats done every 5 m, for a total of 11 quadrats taken on each transect. The two transects done in a phragmites-colonized area are 30 m long because the band of emergent vegetation is thin. The first and last quadrats of these transects fall outside the emergent zone, so if these are discarded, a total of 10 quadrats are taken in this vegetation community. In the past, most of the quadrats were done after the herbicide

application or first goat treatment, but in the future, these will be done in spring before an area is treated.

Percent cover of all species in the meter quadrats is observed and recorded. These data will be compared annually to determine if herbicide, biological, and other control methods are decreasing the percent cover of weed species.

Permanent photo points are set up near these weed transects. From these points, photos are taken in each cardinal direction. Accuracy of these photos is ensured with t-posts for reference (Figure 6.6).

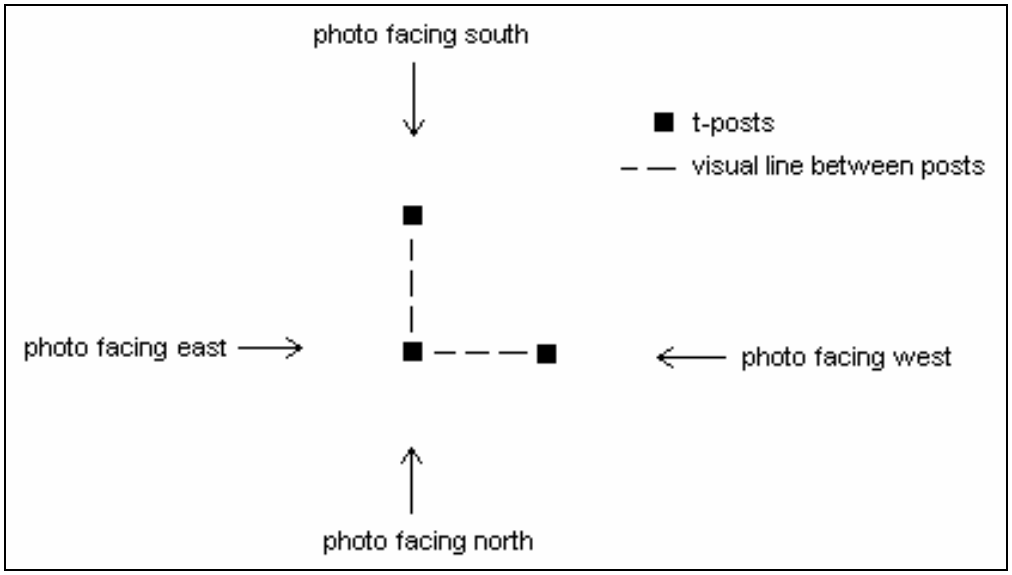


**Figure 6.6. Diagram of photo point set up, viewed from above.**
*Photo accuracy should be high if the t-posts are lined up correctly in each shot from year to year.*

In all cases except for the phragmites transects, the photo points are located at the start of the transect. The meter tape is anchored to the t-post that is situated at the 90° angle and pulled out in the correct direction. Photos should be done after the transect line is in place in order to make the photos align with those taken in previous years.

### *6.2.5. Artesian Well/Slope Wetland Transects*

The artesian wells to be installed in the Alkaline Flats & Slope Wetlands MA will need to be closely monitored because of a high risk of colonization by phragmites, cattail, and other invasive wetland vegetation. Once the artesian wells are installed and the flow of water is established, three permanent transects will be set up perpendicular to the flow in each created slope wetland and species composition assessed along the transect lines (Figure 6.7). At a set interval along these transects, depending on the width, percent ocular cover of vegetation in 1-$m^2$ quadrats will be recorded, as will average heights of dominant species and depth of water.

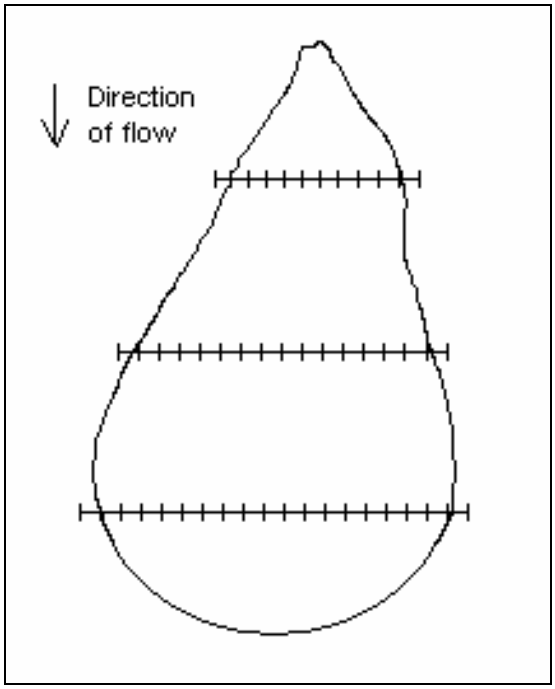


**Figure 6.7. General layout of slope wetland transects to be set up in the Alkaline Flats & Slope Wetlands MA once artesian wells are installed.**

A similar series of transects has been established in the Wet Meadow MA to monitor changes in species composition for two reasons. First, two existing transects were established to monitor for the effectiveness of noxious and invasive weed control. A third transect will be added to the series once the hydrology has been restored (the first two are in remnant wet meadow areas and the third will capture additional area that is inundated by artesian flows). This third transect will also align in a perpendicular direction to flow and will aid in monitoring the reduction of noxious/invasive weeds in the MA.

### *6.2.6. VEGETATIVE MAPPING*

During 2006, the perimeter of weed communities was mapped using GPS, and a visual estimate of the cover of weed species within each community was recorded. Mapping in this manner provided important information regarding the size of the larger infestations, as well as the composition of weed species within those communities. Acreage and overall percent cover of each weed species was indirectly calculated based on the estimate cover recorded for each polygon; yet the level of accuracy was questionable and data processing was laborious. Since only the perimeter of the large polygons were walked and mapped, the center of the polygons may not be accurately represented. Likewise, a second vegetation mapping effort occurred across the LNP detailing habitat type with associated general species composition. Data resulting from the current methods for weed, vegetation, and habitat mapping are not easily combined in a spatial, GIS capacity. In addition, a new set of data needs relative to the success criteria and special conditions outlined in the Section 404 Permit requires assessment of percent cover of noxious weeds and maintenance of wetland-wildlife habitat in good quality. To address this issue, allow for easier data processing in the form of maps and statistical analysis, and implement

more effective management, an alternative mapping technique is proposed for 2007 and future surveys.

Vegetation is a dynamic system that varies in species composition and spatial structure by habitat and season. The floristic composition of vegetation includes all species occurring within a plant community, including noxious and invasive weed species in addition to desirable plant species. The primary goal of the 2007 vegetation mapping survey will be to characterize as many vegetation patterns as possible during a targeted season that ultimately characterizes species composition within a habitat subclass. Using GIS, a grid system will be generated across the entire LNP. Each grid will be surveyed for percent cover of total vegetation by vegetative community. Cover is normally expressed as a percentage and the maximum cover of any one species or group of species and other cover type in one sample area cannot exceed 100%. The grid system consists of small distinct cells (e.g., 20x20 meter), and the 10-m center of each cell will be loaded into GPS units prior to field surveys to enable the surveyor to walk directly to the center of each cell and record data into a GPS data dictionary. The data dictionary will prompt the surveyor to fill in the following information at every cell:

- Percent cover of weeds and dominant species
- Percent cover of desired vegetation and dominant species
- Percent cover of non-vegetated area (water, bare ground)
- Habitat type (evaporative basin, salt meadow, shortgrass prairie, etc.).

Vegetation communities are dictated by seasonal variation. Of particular interest here are phenological patterns over the course of a year. Many plant communities have distinct seasonal peaks of growth and flowering activity, and different components of the vegetation often grow at different times of year. Moreover, weed management and restoration implementation efforts will alter plant communities over time. A second mapping effort in the fall will capture these dynamic processes.

A consolidated mapping effort would be cost effective and would provide a complete raster database for GIS software that will enable more robust vegetation modeling efforts and statistical analysis. This technique creates a repeatable database for future surveys such that vegetative community or population size (e.g., noxious weed infestation) or aerial extent of habitat subclass (e.g., evaporative basin) can be tracked through time. Additionally, effects of management practices can be tracked and monitored through time for the same clusters of cells/pixels rather than relying on on-the-ground observations alone.

### *6.2.7. BIRD SURVEYS*

New avian monitoring protocols were being designed for the 2007 field season at the time of this report. The previous monitoring efforts, from 1999 to 2006, were done in the following manner: eleven bird transects (A though K) and one point count area (point count L) were used to monitor bird populations in the LNP. Transects were surveyed by slowly walking the route of the transect and recording any birds seen within 100 m of both sides of the transect line. Only birds perched, on the ground, or in the water were recorded (flying birds were disregarded because they cannot be directly tied to the transect, however, if significant numbers of individuals were seen flying overhead they are noted as a general comment). Surveys began within an hour of sunrise and end before noon. An 8-×-22-power binocular was used to help in species identification.

At the beginning of each sample day, temperature, percent cloud cover, wind speed, direction, and other general weather comments were noted. Start and end times, elapsed time, presence of surface water, estimated surface water coverage, livestock presence, and general comments were also recorded. The general comment section was used to note observations of predators, human activity, estimated flow rates, Bald Eagle activity, and other miscellaneous occurrences.

Walking transects A through K and point count L were surveyed on the following schedule:

- March 15 through May 14, weekly
- May 15 through July 14, twice a month
- July 15 through October 31, weekly
- November 1 through January 31, monthly
- February 1 through February 28, twice a month

In addition, an avian noise study is being conducted on the LNP to assess the cumulative impacts of noise on bird populations. It is part of a larger research project within the GSL ecosystem gathering data on density, diversity, distribution and productivity of breeding birds in study areas adjacent to interstate highways. The researchers employ point count methodology for this study. For comparability to this and other regional studies, bird transect surveys currently implemented on the LNP may be modified to include point count protocol.

### *6.2.8. Small Mammal Surveys*

The purpose of a live small mammal trapping survey at LNP is to assess the diversity and potentially abundance of different rodent species present within a particular habitat. This type of trapping method limits the trapper's direct exposure to the animals captured and helps minimize and avoid transfer of diseases from rodent to human or vice versa. The following protocol should be followed when conducting small mammal surveys at LNP, to remain consistent and provide comparable data from year to year.

#### Trap Array Protocol

A conservative small mammal survey at the LNP was designed for multi-habitat assessments. The design consists of an array of traps that is repeatable over several habitats: 50 traps per array, set on 10-m centers in a 5-×-10-$m^2$ area. Each array can be set and checked for 3 days by one or two people, which will provide wildlife biologists with enough data for year-to-year comparisons. Ideally, 10-×-10 trap arrays, or 100 traps total, should be used if time and man-hours are available. Traps used and safety issues are detailed in the Small Mammal Trapping Protocol (Appendix D).

Site selection depends on what data is desired from the trapping exercise. In the case of the LNP, baseline surveys are designed to record which small mammal species are present in each habitat surveyed. In subsequent years, the trapping effort can be expanded to survey other habitat types where no baseline data exists or in areas where habitat quality is degraded and expected to improve. For example, little is known of small mammal use in LNP riparian and wet meadow/ salt meadow habitats, or in areas where new habitat is to be created (emergent marsh, slope wetlands). It would be beneficial to monitor species diversity in these areas to contribute to the overall understanding of how each area is functioning as a habitat. Likewise, as an area is improved, it would be helpful to know whether species that are expected to inhabit that area are

present as an indication of how the area is functioning as a habitat. The frequency of trapping in any one area can be scheduled on an annual basis with focus on areas where baseline data is needed versus areas that are expected to improve in association with different management practices. During 2006, one baseline, 5-×-10-m² trap array was set up in a grassland habitat, and a second array in an alkaline knoll habitat. Future studies may also investigate relative abundance of small mammal species using mark-recapture methods.

Timing is an important issue when conducting a small mammal survey. Late summer and early fall are the most ideal times to trap rodents, as they are less likely to have young. This minimizes the effects that the survey has on the rodent population and its reproductive success. Any females caught should be checked for lactation, which would indicate the presence of young. "Wet" females should be processed and released as quickly as possible to return to their litter.

Setting up the trap array is best accomplished using two people, though one person can also set up an array, but with less efficiency. Trap arrays should be set up at least 5-7 days in advance of baiting. This will allow time for animals to acclimate to the presence of traps prior to the traps being set. Traps are left with the door closed on these initial days to avoid accidental trappings. The corners of the trap grid should either be posted with a permanent feature, such as a t-post or PVC stake, or GPS coordinates can be taken at each corner to eliminate the presence of human structures that are visible on the landscape.[3] A plastic tape measure should be used to measure 10 m between each trap location. Each trap location in the grid is then marked temporarily with flagging tape or wire stakes with vinyl flagging. Some liberty can be taken on a smaller scale to decide where to place each trap, to increase the chance of successful capture at that site. For example, if a rodent burrow is found a couple of feet away from a trap point, the trap can be placed closer to the burrow to improve chances of capturing that individual.

### Baiting Traps

Bait for traps can be prepared a day or two in advance so that it is ready to go on the first day of trapping. Usually it is most convenient to make enough bait to last the entire 3 days of the survey, so that it is not introduce disturbance during the survey. To make bait, simply mix peanut butter and rolled oats to create a mix that has the approximate consistency of modeling clay. Roll chunks of the bait into small, dime or nickel sized balls. To reduce mess in the traps, each ball of bait can be wrapped with a perforated piece of wax paper. This basic recipe can be modified to include other ingredients, in order to attract a wider variety of small mammals. For instance, beef or chicken bullion can be crushed and mixed into the bait to attract shrews. For LNP, a mix of bullion, peanut butter, and rolled oats is be used to attract as wide a variety of small mammals as possible.

Traps should be baited in the evening, as close to dark as possible to minimize the time an animal spends in the trap before morning checks for captured individuals. To bait traps, open the front door on each trap to set. Test the sensitivity of the treadle at the back of the trap by pressing lightly on the back door or treadle to trip the spring (depends upon which model trap you are using). Adjust the sensitivity of the trap as needed by bending the treadle arm slightly against or away from the front door of the trap. Once the proper sensitivity is achieved, drop a ball of bait and several cotton balls into the back of the trap. Ideally, the bait should be sitting on top of the treadle. The cotton balls are meant to provide overnight insulation for a captured mammal, and

[3] For GPS coordinates please use UTMs, NAD 83 datum.

do not necessarily need to be on the treadle when the trap is set. Gently place the trap with the front door open on the ground. The opening can and should be placed towards any nearby burrows, to encourage capture. Traps can then be covered with ground litter or debris if desired. This will insulate the trap a bit better, but it will also make the trap more difficult to relocate in the morning. The surveyor can make this judgment on a case-by-case basis.

### Checking Traps

Traps are to be checked by surveyors as soon after sunlight as possible, to minimize the time an animal spends in the trap and reduce stress and fatalities. During trap checks, surveyors should wear rubber gloves to protect against diseases carried by rodents. Actual handling of animals in this type of survey should be minimized, as there is no need to directly handle the animal to identify it to species in most cases. Instead, use a gloved hand to hold the front door of the trap open, and tip it at an angle into a quart-sized Ziploc baggie with holes punched into it. This will allow the surveyor to view the animal without having to handle it. Be sure to have several baggies on hand for use, as one may eventually tear or become soiled. Take enough time to positively identify the species caught, and if possible, check gender and reproductive status for females (lactating or not). Record the data on the data sheet (included in SWCA 2006c), open the Ziploc bag, and release the rodent as close to the capture point as possible. Replace the trap to its spot on the ground, leaving the doors closed to avoid new captures during the day. Traps will be rebaited if necessary, and set again later in the evening once again. A total of three consecutive trap nights is typical for this type of survey.

Leather gardening gloves should be carried as they can be as well. There may be some cases where surveyors must handle the animal caught, to coax it out of the trap, Ziplocs, or other cases where thicker gloves will be handy. Leather gloves will also help to avoid scratches or bites in cases where larger rodents or mammals are caught that do not fit into the Ziploc bag for processing.

### Recording Data

The data form should be used to collect all the necessary and useful data for small mammal trapping surveys. It is most efficient to have two people running trap checks, one who handles the traps and the other who records data. Any rodents that perish in the traps prior to a morning check can be collected in a plastic bag and examined more closely later, if it is desired by the surveyor(s). For example, vole species can be difficult to identify by sight, and often perish in traps due to their high metabolism. If a dead shrew or other species is found during a trapping survey, it can be taken back to a lab, where the dentition can be studied more closely to determine species. To understand dental formulas and key out mammal dentition, please see "A Key to the Skulls of North American Mammals" by Bryan P. Glass and Monte L. Thies (1997).

## 6.3. QUANTITATIVE SUCCESS CRITERIA

### *6.3.1. FRAMEWORK*

Monitoring protocols have been established throughout the LNP to assist in determining whether the landscape is responding to management practices in a positive way. Information collected during surveys is both descriptive and empirical such that statistical analysis can be applied to a specific metric. Ideally, there would be reference data available from a network of similar

systems by which to compare. However, complete reference data is currently not available so reference standards are not a possible comparison. Alternatively, baseline data can be used as either a static benchmark or a reference beyond which improvements can be made.

### *6.3.2. Success Criteria for Vegetative Survey Monitoring Protocols 1 through 5 for the Jordan River Floodplain*

**Protocols:**

- Transects through evaporative basins and floodplain areas
- Relevé plots within alkaline flats
- Monitoring noxious and invasive plant control measures
- Monitoring success of created and restored slope wetlands from artesian well flows
- Mapping vegetation/habitat subclasses and noxious and invasive weeds

**Metrics:**

Species composition and percent cover and percent cover of invasive/noxious/introduced versus native/naturalized species.

**Success Criteria:**

- Each habitat subclass of an MA can have no more than 20% noxious or invasive species as determined by noxious and invasive species weed mapping data.
- 80% of each habitat subclass traversed by transects or assessed by relevé plots and vegetative mapping must meet the subclass descriptions in Chapter 2 of this document, and species present must be comparable to the associated species list in Appendix H, Habitat Schemes.

**Notes:**

Species listed in Appendix H are species that can potentially occur. Not all species are to occur simultaneously, particularly since the floodplain will cycle through wet and dry years and various levels of salinity in certain areas. Greater than 50% dominance of subclass species will classify a quadrat as that respective habitat subclass. Transects will be divided into habitat subclass designations based on habitat classification map and hydrologic regime. If an area does not respond to the applied hydrology as expected, then the habitat classification will need to be adjusted to what can reasonably be expected to develop. Quadrats that fall within the revised area will be tested for the new habitat classification.

### *6.3.3. Success Criteria for Bird and Small Mammal Surveys at the LNP*

**Metrics:**

Species composition (as species richness), or Shannon's diversity index.

**Success Criteria:**

- In areas where there is no major habitat change (e.g., existing salt meadow and wet meadow, alkaline flats), bird and small mammal usage is expected to stay at least the same as baseline average (except during flood years).

- In areas where habitat is created or enhanced for a particular guild(s) or mammal(s), post-mitigation data will show significantly higher use by expected individuals of a guild(s)/small mammals than the baseline average. Examples of habitat areas are wetlands that develop in association with the North Canyon Meander, created slope wetlands, improved/expanded evaporative basins, and shortgrass prairies.
- In areas where noxious and invasive weeds are being controlled, post-mitigation data will show significantly higher use by expected individuals of a guild(s)/small mammals than the baseline average. Simple regression analysis can be used to assess statistical significance.

**Notes:**

Statistical comparisons are to be made between the baseline average and each post-mitigation monitoring year. There is no need to show a statistical trend among post-mitigation years because of ecological and climatic variability, which are beyond the LNP manager's responsibility and control. MAs will meet bird small mammal compliance once habitats within them meet the success criterion/criteria appropriate to the management objective for three consecutive years. An area may be exempt from meeting success criteria for small mammals if management practices and objectives preclude the use of the area by small mammals.

## 6.4. ADDITIONAL MONITORING NEEDS

As the LNP is managed for the improvement of habitat and overall ecological integrity, data gaps that could provide additional information to guide management decisions will become apparent. Some of the monitoring needs that have been identified are listed below. This list is not meant to be exhaustive, yet information gained by the suggested monitoring will aid in the understanding of how an area's habitat is functioning or how a habitat might be improved.

- Monitor evaporative basins to better understand water and soil chemistry parameters that are suitable for high macroinvertebrate productivity.
- Monitor macroinvertebrate monitoring in evaporative basins to assess quantity and quality of food base for shorebirds.
- Monitor for nest predation and nesting success rates of birds at the LNP to justify lethal control or trapping of native mammalian predators at the LNP if predation is suspected of being a management issue.
- Monitoring grazing efficacy so that target plant species are suppressed yet habitat and wildlife is not compromised by overgrazing.
- Continued monitoring in areas that have native and other desired plant species for outbreaks of non-desirable plants (noxious and invasive species).
- Monitor Wet Meadow MA wetlands for adequate (12 acre) inundation from artesian wells as directed in the CWMP.
- Monitor all other water prescriptions as directed in the CWMP.

## 6.5. ADAPTIVE MANAGEMENT

The LNP management and Scientific Advisory Committee (SAC) will review the results presented in the annual resource reports to determine whether implemented management

practices are achieving desired effects. Specifically, the annual vegetative, noxious weed, bird, and small mammal monitoring reports should be reviewed. Review should take place during the early winter so that recommended modifications to the management practices can be planned no later than the end of March each year. The management and SAC should also include in their review any additional descriptive surveys that will help determine responses to management practices and identify areas that are in need of adjustment in management actions.

Once an MA meets acreage requirements listed in Table 6.1 and quantitative success criteria for vegetation and birds/small mammals for three consecutive years, a request for meeting Section 404 permit compliance can be submitted to the USACE for that MA. After compliance of an MA is approved by the USACE, management practices and necessary monitoring to keep that area functioning in as good or better condition will need to be identified by the management and SAC. Together, management and the SAC will determine an appropriate schedule for management practices and monitoring to maintain the same level or better quality of habitats within each MA as they are approved for Section 404 permit compliance.

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# APPENDIX A. NESTING ECOLOGY OF BREEDING BIRD SPECIES

**(Source: Cornell University "Birds of North America" online database)**

## NESTING SPECIES LISTED AS PRIORITY BY BEAR RIVER MIGRATORY BIRD REFUGE (BRMBR), UTAH PARTNERS IN FLIGHT (UPF) AND/OR UTAH SENSITIVE SPECIES (USS):

### *AMERICAN AVOCET (UPF, BRMBR)*

In Utah, arrival is in late March. Nesting occurs from mid-April to mid-July. Pairs will renest if initial nest is depredated or heavily disturbed. Nest building is completed immediately before egg-laying. Nest scrape in soft substrate of alkali, dike, or island; associated with water's edge, usually in sparse vegetation (such as glasswort or salt grass). Islands constructed for waterfowl nesting are used if not overgrown with grasses and forbs. Nests on islands when available, which provides partial protection from predators. On islands or shorelines, nests often slightly elevated (2–10 cm) from surrounding substrate. Generally, incubating bird has a clear view of 270–360°, unobstructed by vegetation. Rarely, nest completely surrounded by water. There is a strong tendency to nest in loose colonies, but pairs will also nest alone.

### *BLACK-NECKED STILT (UPF, BRMBR)*

In Great Salt Lake Valley, UT: arrival late March. Nesting begins late April; latest clutches initiated mid-June. Only one brood produced per season. Nest building completed immediately prior to egg-laying. Nest scrape in soft substrate of alkali flat, dike or island. Often over water on small islands or vegetation clumps. Although nests often completely in the open, at some sites nests surrounded by a mean of 56% vegetative cover ($n$ = 47 nests), mostly glasswort and frakenia (*Frankenia grandifolia*. In tidal impoundments with 95% open water, flooded salt-meadow cordgrass (*Spartina patens*) and saltgrass (*Distichlis spp.)*. Along water's edge of impoundments in clumps of barnyard grass (*Echinochloa crusgalli* var. *crusgalli*) or Bermuda grass (*Cynodon dactylon)*. Also found on dead remains of cattails protruding above the waterline, short emergent vegetation stubble over water, and on dikes, islands, or high spots with sparse vegetation, particularly glasswort and saltgrass (*Distichlis stricta*). Nest site often slightly elevated (2–10 cm) from surrounding substrate. In Utah, 74% of nests were found in vegetation, others in the open. Islets are highly preferred for nesting.

### *BALD EAGLE*

Nest building for Bald Eagles in Utah typically begins around February, though adults with an existing nest will repair it year-round. Pairs only have one brood attempt per season, though removal of eggs has resulted in the laying of replacement clutches in some studies. Clutches tend to be laid in March or early April. It is unclear which sex is responsible for nest-site and nest-tree selection. Observations of females defending territories and attempting to attract mates suggest that females may select sites. In suitable areas, the nest tree is generally one of largest trees available with accessible limbs capable of holding nest. Cottonwoods and aspens (*Populus* spp.) are used as nest trees where large conifers are absent. Pair usually builds nest in live tree, although adjacent snags (dead trees) are used for perching. Nest is usually placed against trunk or in fork of large branches close to trunk, in the top quarter of the tree. In treeless areas, ground nest sites are usually on prominent ridges, cliff sides, or sea stacks with good flight access but limited ground access for potential predators. Artificial platforms are also used in the absence of

tall trees. Nests are repaired and reused from year to year, and are among the largest nests of all birds. Bald Eagles will often have an alternate nest site within their territory, and may switch to that site in successive years.

### *BREWER'S SPARROW (UPF, BRMBR)*

Birds arrive in April with males arriving a few days before females in order to establish territories. Nesting season extends from mid-Apr to early August; most nesting activity concentrated between mid-May and late July. Produces replacement clutches and frequently double-broods. Renesting begins soon after loss of first nest. Second broods are initiated approximately 10 d after first brood fledges. Compared with surrounding habitat, nests located in significantly taller, denser shrubs (primarily big sagebrush) with reduced bare ground and herbaceous cover. Available cover may be primary factor in nest-site selection. Nests are toward edge of densest portion of sagebrush relative to nests of Sage Sparrow and Sage Thrasher. Most nests built in big sagebrush, dominant shrub of n. Great Basin shrub-steppe. Also nests spiny hopsage (*Grayia spinosa*), antelope bitterbrush (*Purshia tridentata*), and green rabbitbrush. Prefers nest shrubs entirely alive or mostly alive. Foliage of live shrubs provides concealment from predators and protection from elements. Do not reuse nests from year to year.

## POTENTIAL PRIORITY/NESTING SPECIES:

### *PIED-BILLED GREBE*

Breeding season for Pied-billed Grebes in the Salt Lake Region is dependant upon open water and availability of food, which varies highly to include crustaceans, fish, invertebrates, and amphibians. Nesting season can be highly extended in some areas and may range from early April and continue nearly into fall months. Renesting is common following a failed nest or lost eggs; second broods are possible after a successful first brood, but are not the rule. Nests consist of a floating platform of dead aquatic vegetation, most commonly built among tall emergent vegetation on the edge of marsh habitat. Platforms are usually anchored in some way to emergent vegetation, so the nest does not float freely into open water. Grebes prefer the presence of emergent vegetation to conceal their nest, as well as having fairly deep (> 25 cm) water adjacent to the nest to facilitate escape and feeding. Eggs left in the nest are concealed and covered with vegetation by the adult before it leaves to forage.

### *SNOWY EGRET*

One of North America's most familiar herons, the Snowy Egret is known for its beautiful breeding plumage and animated foraging behavior. Pairs typically nest in mixed-species colonies where the Snowy is often one of the most abundant species. Island nest sites are preferred because they are less vulnerable to predators than mainland and peninsular sites. Breeding and nesting season tend to start around mid-April to early May, beginning with courtship and leading to nest building or repairing. Snowy Egrets use old nests as well as constructing new ones. Snowies have one brood per season, but will often renest if the first attempt fails. Nest sites generally favor isolated estuarine sites, particularly inland lakes and rivers in the Western United States. Egrets will nest in a variety of species, from Phragmites to shrubs, cedars and deciduous trees, in branches further out from the trunk. Nest sites are usually proximate to water.

### *WHITE-FACED IBIS (BRMBR)*

The species is locally common, nesting in several marshes in the western United States, including the Salt Lake Region. Pair formation and nest-site selection occur mostly from mid-April to mid-May, shortly after ibises arrive from wintering areas in early or mid-April. Eggs are laid from last week of April through second week of June. Ibises may attempt a second nest following the destruction of their initial nest attempt. This species usually nests in emergent vegetation or low trees and shrubs over shallow water; or occasionally on the ground on small islands. Nesting above water or on islands presumably affords some protection against terrestrial predators. Favorite plant species for nesting include hardstem bulrush, alkalai bulrush, and cattail, and tamarisk. Colonies often develop at existing roost sites, and some colony sites are used repeatedly over several years.

### *GADWALL*

Gadwalls are a monogamous, year-round resident of the Salt Lake Region, and are commonly seen in the wetlands habitats at the Legacy Nature Preserve. Gadwalls nest on the ground in tall, emergent vegetation near water and prefer islands; giving it a higher rate of nesting success than ducks that nest in more open habitats. They commonly have only one brood per breeding season, and nest later on average than other dabbling ducks. For the Salt Lake Region, Gadwalls tend to initiate nests anywhere from late May through mid-July. They will make a second nest attempt if the first is destroyed or depredated. Nest sites are selected in fields and meadows, and on islands and dikes in marshes. Nests are typically found in dense brush, forbs, and/or grasses in dry areas, often near open water.

### *CINNAMON TEAL (BRMBR)*

This duck inhabits mostly freshwater or brackish wetlands, including the highly alkaline waters of the Great Basin. Females construct a well-concealed nest near water in rushes, sedges, and grasses, or sometimes over water in dense bulrushes or cattails. In Utah, Cinnamon Teal have been recorded nesting from late April to late July. Nests are often placed below matted, dead stems of vegetation so that the nest is completely concealed on all sides and above. Females approach the nest via tunnels in the vegetation. The nest itself is a scrape lined with dead grasses. Nest habitat often consists of rushes, saltgrass, bulrushes, or grasses, with close proximity to water.

### *WOOD DUCK*

The Wood Duck is a common bird of riparian habitats, wooded swamps, and freshwater marshes. It is unique from other duck and teal species at LNP in that it is a cavity nester. Nest boxes will likely be necessary at LNP to provide sufficient breeding habitat, should the Wood Duck become a priority species for management. Nesting can begin as early as February, depending on weather, and can extend through May and June. The Wood Duck is the only North American duck that regularly produces 2 broods in 1 breeding season. Wood ducks do not create their own nest cavity, but rather occupy cavities created by other species. Very rarely, they will nest on the ground. Mature forests are normally needed for development of trees with suitable cavities; however, artificial nest boxes can be used as a substitute. Birds prefer sites close to or over water and near good brood-rearing areas. Cavities average 7.3 m above ground with higher

sites preferred. Wood ducks also prefer cavities or nest boxes with smaller openings rather than larger.

### *VIRGINIA RAIL*

A secretive freshwater marsh bird similar to the Sora Rail, Virginia Rails are also more often heard than seen, though they are more of a generalist regarding habitat than the Sora. Within its range the Virginia Rail is restricted to isolated wetland areas, but can be locally abundant if habitat conditions are favorable. Nest building likely begins in May, with the height of egg-laying occurring in late May and early June but may continue through July. Adults build numerous "dummy" nests within their territories in addition to their primary nest. Two successful broods in one breeding season are possible, though this has not been well studied for Virginia Rails. Nests are made in robust emergent vegetation (e.g., cattails, bulrush). Virginia Rails will nest within a wide variety of emergents, so the dominant plant species in a marsh is not considered a good indication of habitat suitability. Nests are well concealed; often built touching water, slightly submerged below, or a short distance (< 15 cm) above water surface. Nests are most often built along the boarder between emergent vegetation types.

### *SORA*

The most abundant and widely distributed North American rail, the Sora breeds primarily in freshwater marshes dominated by emergent vegetation. It is more often seen than heard, since it frequents dense emergent vegetation both for feeding and nesting. It arrives from its wintering grounds during late April or early May, and nests are initiated from May until early June. Later nests initiated in July are thought to be second nest attempts following a failed first nest. Usually nests in robust or fine-leaved emergent vegetation with shallow (18–22 cm) water. Dominant plants at nest sites include cattail, sedges, and, less commonly, bulrushes, burreeds, or grasses. Preferred nest sites seem to be in cattails or sedges, especially near borders between vegetation types or patches of open water.

### *LONG-BILLED CURLEW (UPF, USS)*

The Long-billed Curlew is a shorebird endemic to short and mixed grassland habitats throughout the midwestern and western portions of the continent. Pair formation on the breeding grounds is highlighted by a conspicuous aerial display. Both sexes incubate, rear chicks, and are aggressive in defense of nests and young. Curlews are particularly sensitive to human disturbance during the breeding season, and thus this species is listed as one of concern or special interest with state agencies and local conservation groups. In Utah, breeding Curlews tend to arrive in mid- to late March. Nesting is initiated from early April through May, with hatching occurring mostly in late May. The nest bowl consists of a shallow depression in ground. Nest bowl may be lined with small pebbles, bark, livestock droppings, grass, rabbit or Canada Goose droppings, small stems, twigs, seeds, and cheatgrass leaves In Utah, nests have been reported in clumps of thick residual and growing vegetation with relatively little bare ground present. Relatively dry, exposed sites are generally chosen for nests, but some variability has been observed. Nests are often located near conspicuous objects, including livestock dung piles, rocks, and dirt mounds. It is thought that pairs may intentionally place nests near these objects, possibly to provide shade, increase camouflage, or facilitate nest location by the breeding pair.

### *WILSON'S PHALAROPE*

Wilson's Phalarope is the largest and most terrestrial of the three phalarope species, which are well known for their reversed sex-role mating system – males alone incubate and brood chicks. It is unknown whether or not they breed at the Legacy Nature Preserve; however, it is widely known that the Salt Lake Region serves as a major staging area for Wilson's Phalaropes prior to their winter migration to South America. Courtship displays and pair-bonding tend to occur in April and early May, with nests being initiated from mid-May through June. Both adults participate in selecting a nest location, which tends to be either among vegetation along a wetland edge or in upland areas within 100 m of wetlands. Phalaropes tend to select areas with mixed plant species, rather than a homogenous stand of one vegetation type. Nest sites tend to be in more dense vegetation compared to other prairie-breeding shorebirds.

### *FORSTER'S TERN*

A "marsh tern," this species breeds primarily in fresh, brackish, and saltwater marshes, including marshy borders of lakes, islands, or streams. It is found more often in open, deeper portions of marshes, generally in wetlands with considerable open water and large stands of island-like vegetation and/or large mats of floating vegetation. Forster's Tern have one brood per breeding season, but will renest if a first attempt fails. Terns nest later in the breeding season than many birds, generally waiting until mid-May or June before laying their first clutch. The precariousness of their nests, which are built loosely of reeds and vegetation and often float on the surface of marsh waters, makes nest failure common. The majority of terns will thus renest after failed first and second attempts. Nests are often built very near open water, on clumps of vegetation, on top of muskrat lodges, or on islands to reduce chances of predation. Forster's Terns may also use a simple scrape in mud, or an abandoned grebe nest. Nests are frequently arranged in loose colonies.

### *RED-TAILED HAWK (KNOWN NEST)*

The Red-tailed Hawk is one of the most widespread and commonly observed birds of prey in North America. Currently at LNP there is at least one nesting pair of Red-tails, using a pylon along the electrical right-of-way in the Alkaline Knolls/Slope Wetlands Area. Red-tailed Hawks are year-round residents of the Salt Lake Region, though they may move to different habitats in the winter in pursuit of food resources. Nest building begins in February, and pairs may refurbish and reuse the same nest over several years, or have several older nests that they refurbish and select from each year. First eggs tend to be laid in mid to late March, and only one brood attempt is made per breeding season. Red-tailed Hawks use a wide array of habitats and sites for nesting, from cliff edges and ridgetops, to tree canopies and dead snags, to artificial and man-made structures. As long as there is ample food base, Red-tails will occupy nearly any habitat type.

### *PEREGRINE FALCON (KNOWN NEST)*

Among the most studied of wild avian species, Peregrine falcons have a world-wide distribution, and are ubiquitous to a wide array of habitats and metropolitan settings. Currently at LNP, there is a breeding pair of Peregrines using an old hawk or raven nest on an electric pylon in the Alkaline Knolls/Slope Wetlands Area. Historically Peregrines nested on cliffs; but increasingly, they use other unconventional nest sites such as old Common Raven (*Corvus corax*) nests on electric pylons, Osprey (*Pandion haliaetus*) and cormorant (*Phalacrocorax* spp.) nests on

channel buoys, abandoned Bald Eagle (*Haliaeetus leucocephalus*) nests, an dead tree snags, and special towers in salt marshes. They do not build nests per se, but will either create a scrape or use abandoned nests of another large bird species. Peregrines only raise one brood per breeding season, though they may renest if eggs are destroyed early on. The start of nesting season is highly variable, but most likely coincides with the nesting season of other raptors in the area, beginning in early to mid-march and continuing until young fledge in late June or early July. If food is readily available year round, Peregrines may choose to remain overwinter rather than migrating.

### *YELLOW-BILLED CUCKOO (UPF)*

Primarily a bird of the Eastern United States, the Yellow-billed Cuckoo also has established scattered populations in the west, including the Salt Lake Region. Cuckoos are facultative, interspecific brood parasites, meaning that they may choose to build their own nest, or lay their eggs in the nest of other species. When parasitic, they tend to favor the nests of thrush species to lay their eggs, particularly those of American Robin, Catbird, and Wood Thrush, but also Red-winged Blackbird. The will also parasitize the nests of other cuckoos. Cuckoos are also known to practice cooperative breeding, where more than one female will tend to and feed young. When nests are built by a pair, they are typically placed on a horizontal branch or vertical fork of a tree or large shrub; usually 1–6 m above ground, but observed as high as 27 m. Generally nests in groves of broad-leafed deciduous hardwoods with thick bushes, vines, or hedgerows providing dense foliage within 10 m of the ground. In arid regions, nesting is restricted to river bottoms, ponds, swampy areas, and damp thickets. It is unknown whether or not cuckoos nest at the LNP.

### *BARN OWL (KNOWN NEST)*

Barn Owls are another widespread species, and are likely the most widespread of the owls worldwide. A nesting pair has existed at the Legacy Nature Preserve, using the Swallow Barn as their nesting and roosting site. Pairs form a bond fairly early, and in Northern Utah, some pairs have been recorded roosting together in potential nest sites as early as November. Nesting and egg laying in the Salt Lake Region begins around mid-March, but clutches may be laid later if the previous winter produced deep snow and lower than average temperatures. Barn Owls may have two clutches per season, with the second brood initiated around mid-July. Second clutches may be started before the first is fully independent, and may be at the same nest site or a new one. Nests are often built in human structures such as barns or sheds (thus the common name), or may be built on cliffs, dug into arroyos, or in tree cavities. Nest boxes may be used to encourage pairs to nest in an area. Nest sites are often reused for many years.

### *SHORT-EARED OWL (USS)*

One of the worlds most widely distributed owls; the Short-eared Owl is an open country, ground-nesting species that inhabits marshes and grasslands in the Great-Basin region. Breeding pairs have not yet been confirmed on LNP, though there is favorable habitat present for breeding owls. Perhaps because of loss of habitat, this owl is listed as a sensitive species by UWDR. Its population size and breeding success are tightly linked to the fluctuating density of its primary prey – mainly voles and other small rodents. Pair formation and courtship (which includes "sky-dancing" displays by males) begin in mid-February and can continue through June, though most pairs nest around the month of April. Though it has not been confirmed with rigorous research,

Short-eared owls are thought to be capable of having two broods in one breeding season. Nests are a scrape on the ground formed by the female, and often conspicuously lined with grasses and feathers. Short-eared owls are one of few owl species that construct their own nest rather than using abandoned nests of other birds. This species usually nests on dry sites, often on small knolls, ridges, or hummocks; wet areas are used less frequently. Females incubating eggs or chicks are often "stickers" – meaning that they will stay on the nest and only flush when a human or predator is less than a meter away. Males, if nearby, will display and vocalize to distract potential predators.

### *BURROWING OWL (USS)*

Burrowing Owls are a unique, ground-dwelling species of owl that nest in most of the Western United States. Anecdotal observations indicate that there may be Burrowing Owls breeding on LNP; though further observations are necessary to confirm this. Abandoned fox dens on LNP may provide nesting habitat for Burrowing Owls. Breeding season begins in late March or early April, when males return and begin courtship and territorial behavior. There are no known records of Burrowing Owls producing a second brood in its western range; though renesting may occur if the first nest is destroyed early in the breeding season. Owls tend to select their burrows in areas with other burrows, close to roads, surrounded by bare ground or short grass. The highest preference for nesting areas is given to areas with a high density of nearby burrows available. Availability of conspicuous perches nearby may also factor into the selection of nest sites. Burrowing owls will reuse the same burrow from year to year.

### *WESTERN KINGBIRD*

The Western Kingbird is a conspicuous bird of open habitats that breeds in the western United States and winters in southern Mexico and Central America. It occupies a variety of habitats including riparian forests and woodlands, savannahs, shrublands, agricultural lands (pasture and cropland), deserts, and urban areas. Nesting activity tends to begin at the start of May, with peak egg-laying around late May and early June. Kingbirds tend to rear only one brood per season. They are flexible in their selection of a nesting structure; thus nests built on a variety of natural and human-made structures, although nests are more frequently built in trees or shrubs. Preferred tree species include Cottonwood, Willow, Box Elder, and Green Ash. Nests are usually built on a horizontal branch or the crotch of upward slanting branch, well within canopy as opposed to at the end of a branch. Height of trees/shrubs used for nesting and nests themselves varies greatly depending on the habitat and the tree species selected.

### *WILLOW FLYCATCHER (UPF, USS)*

The Willow Flycatcher is a common migratory species that breeds in a variety of usually shrubby, often wet habitats from Maine to British Columbia and as far south as southern Arizona and southern California. The southwestern subspecies, *E. traillii extimus*, has been federally listed as endangered and thus it is listed here in case any breeding pairs are found at LNP. Because the Willow Flycatcher is restricted to river corridors in the arid parts of the West, it is vulnerable to a variety of human activities that may alter or degrade such habitats, activities including river dewatering, channelization, overgrazing, dam construction, and urbanization. It begins nesting later in the breeding season than many neotropical migrants, generally in early to mid-June, and only has one brood per season. It will however renest after a failed first attempt.

Nests are built low in the crotch of a bush or small tree near water; close to ground in low shrubs and bushes. It often selects willow shrubs for nesting, thus its name. It will however utilize other species near water, such as tamarisk, box elder, and dogwood species.

### *YELLOW WARBLER*

Aptly named, the Yellow Warbler is found throughout much of North America in habitats briefly categorized as wet, deciduous thickets. One common feature of Yellow Warbler habitat is the presence of various species of willows (*Salix* spp.). The height of nesting season falls between late May and early June, and only one brood is reared per season. Nests are built in the upright fork of a bush, sapling, or tree. Willows are the most preferred nest tree species, though Yellow Warblers will also nest in hawthorns, honeysuckle, raspberry, dogwood, and other woody shrub or tree species associated with wet soils. Nests themselves are soft, delicate cups formed from grasses, animal fur, and the fibers of airborne seeds (e.g. cottonwood).

### *COMMON YELLOWTHROAT*

This inhabitant of thick, tangled vegetation (particularly in wet areas) is one of North America's most widespread warblers, breeding throughout the continental United States. Nesting may occur anytime between mid-April and early July. There is no research showing that yellowthroats have second broods; thus it is assumed that they only raise one brood per season. Nests are typically built on or near (within 10 cm) the ground; ground nests are placed in higher, drier areas and above-ground nests tend to be in marshy areas where rising water could inundate nests. Vegetation surrounding the nest provides concealment and protection from the sun. Nests are supported by sedges and grasses of various species, and may rarely be placed over water.

### *BLACK-HEADED GROSBEAK*

This common species breeds from subalpine forests to desert riparian zones throughout western North America. Nest-building begins in late April or early May, and egg-laying occurs from late April until late June. There are no records of second broods. Nests are typically placed in the outer branches of a small deciduous trees or bushes, often near a stream. Common tree species include willow, live oak, alter, cottonwood, and elderberry. The nest itself is an open cup, bulky and loosely constructed with no mud.

### *GRASSHOPPER SPARROW (UPF)*

The Grasshopper Sparrow has an isolated summer range in the West that includes the Salt Lake Region, parts of southern Idaho, and southwestern Wyoming. Thus included as a potential nesting species at the Legacy Nature Preserve, though this has not yet been confirmed by breeding bird surveys or nest searches. Breeding season for Grasshopper Sparrows tends to begin in May. In the breeding season this sparrow generally occupies intermediate grassland habitat, preferring drier, thicker, brushier sites in shortgrass prairie and southwestern grasslands. In general, breeding season is protracted depending upon weather. When weather is favorable, species can produce two or more broods annually. This is critical for a ground-nesting species that generally experiences moderate to high levels of nest predation. Grasshopper Sparrows construct a distinctive ground nest that tends to be very difficult to locate. Nests are usually domed with overhanging grasses and a side entrance, somewhat similar to Ovenbird (*Seiurus*

*aurocapilla*) nest. Nests are typically built in dense grasses, clover, or dead vegetation. Nests are not reused; in subsequent nesting attempts, Grasshopper Sparrows build a new nest.

### *SAGE SPARROW (UPF)*

The Sage Sparrow is a widespread breeder in shrub-steppe habitats from the northern edges of the Great Basin sagebrush expanses west of the Rocky Mountains to the chaparral and sagebrush scrub in Baja California. Although often quite common, this inconspicuous sparrow is frequently overlooked by observers because of its habit of running on the ground from shrub to shrub. Nest building information for the Salt Lake Region is unavailable, but nesting in other regions of similar latitude is from mid-April to June. Eggs are laid during the same period. Nests are built mainly in shrubs, but also in bunchgrass and occasionally on the ground under shrubs. Microhabitat preference is probably based more on structure and density of shrubs than on shrub species. Sage Sparrows prefer taller shrubs with larger canopies, which provide more cover.

### *NORTHERN (BULLOCK'S) ORIOLE*

Bullock's Oriole is a characteristic bird of open woodland in western North America—especially riparian woodlands with large cottonwoods, sycamores, and willows. In western states, nests are constructed from mid-May to mid-June, and eggs are normally laid between mid-June and early July. Nests themselves are intricately woven, hanging structures, often suspended from a few thin branches or less frequently attached to a larger branch. Nests commonly are placed in isolated trees, at the edges of woodlands, along watercourses, in shelterbelts, and are often near water. A variety of tree species are utilized for nesting, including cottonwood, willow, Russian olive, maple, and locust species.

## OTHER LIKELY NESTING BIRDS AT LNP:

### *MALLARD*

In Utah, Mallards can be either migratory or year-round residents. Around urban areas in particular, many mallards become year-round residents, as food sources and open water are associated with suburban parks and neighborhoods. Nesting typically occurs from mid to late April through June, with peak nest initiation in early to mid-May. Spring temperatures, rainfall, and available wetlands also affect the timing of nesting. Low spring temperatures can delay nesting for up to 2 weeks. Mallards commonly renest if first clutch destroyed or abandoned, but rarely raise second broods if the first is successful. Mallards usually nest on ground in upland areas near water; with the nest placed under overhanging cover or in dense vegetation for maximum concealment. Grassland cover includes whitetop (*Scholochloa festucacea*), buckbrush (*Symphoricarpos orbiculatus*), cordgrass (*Spartina* spp.), saltbush (*Atriplex* spp.), nettle (*Urtica* spp.), thistles, prairie grass, and shrubs. In urbanized areas, nests may be built under ornamental shrubs, in gardens, and under patios or other artificial structures.

### *KILLDEER*

Killdeer can be found year-round in Utah. Breeding and nesting may begin as early as March, with broods occurring through July. Later broods are often the result of depredation or disturbance of earlier nest attempts, though some pairs will have two successful broods in one season. Nests are characteristically found in the open, with sparse low vegetation or no

vegetation. Nests occur in both disturbed and undisturbed areas, with pairs often opting to nest on gravel roads and shoulders, or on top of dykes. Often the specific site is raised slightly above surrounding terrain. Killdeer may prefer such sites in order to avoid occasional flooding or to obtain better view of approach of potential predators. Nest sites are not necessarily associated with nearby water. Killdeer commonly feign injury and vocalize loudly to distract potential predators from nests and chicks.

### *WILSON'S SNIPE*

Snipe are year-round residents of the Salt Lake Region, and breeding behavior tends to start in late March or early April. Females will often select more than one site and make several scrapes before selecting one. There are spotty references in the literature regarding Snipes having two broods in one season, though it seems that most have only one brood when successful, or will attempt to renest following the destruction of a first attempt. Snipe nest in wet areas -- very close to or even surrounded by water. Nest sites are often placed on a hummock or on edge in marsh or swamp; rarely on dry grassy hillsides. Nests sites are on the ground and are well concealed in grasses or sedges. In some instances, snipe will nest under an overhung of willow, alder, or other brush.

### *CALIFORNIA QUAIL*

The California Quail is a New World Quail resident in westernmost North America. It does best in broken, scrubby habitat where it has access to cover and to annual food species, mainly legumes. Complete covey breakup and the initiation of egg-laying generally occurs from April to May in most parts of North America, but may be as late as June in the Salt Lake Region due to elevation and persistence of cold weather in the spring. In productive years, females may hatch two broods, though one is typically the norm. Nests are generally on the ground and are well concealed. Habitat for nesting includes areas with grasses and herbaceous plants, as well as bases of trees in sites with early stages of plant succession, on roadsides, and in locations with more bare ground and less grass, shrub and vertical cover. Often built at the base of trees such as willow, but also next to woodpiles, logs, gullies, etc.

### *RING-NECKED PHEASANT*

The Ring-necked Pheasant is a highly successful upland game bird, introduced to the United States from Asia. It occupies open grasslands, and is a year-round resident to the Salt Lake Region. Pheasants generally breed from about early or mid-March until August; females form harems earlier in the breeding season and then nesting continues through the summer. Egg laying tends to peak in late May and continue through August. Ring-necked Pheasants are persistent renesters when a nest is destroyed, initiating as many as 5 nests in a single season. If a brood is successful, than no subsequent renesting occurs. Females select nest sites on the ground with tall vegetation consisting of grasses, weeds, or shrubs. Rarely, pheasants will nest on elevated sites such as straw stacks and old tree nests of other birds or squirrels. If a first nest attempt fails, females may move considerable distance for renesting attempts and often select different cover types.

### *MOURNING DOVE*

Mourning Doves are year-round residents of the Salt Lake Region, with a nesting season that spans from approximately late April through early July. Pairs may have more than one successful brood, but females generally need around 30 days between the initiation of the first clutch and that of any subsequent clutches. Eggs may be laid in a second nest before the young of the first clutch are fully fledged. Mourning doves have a suite of adaptations to allow and promote multiple brooding. Nests are small and sparse, consisting of a shallow bowl. Mourning Doves will occasionally use the same nest twice, or may build on top of the abandoned nests of other species. Nests primarily at woodland or grassland edge, usually in trees but readily on ground in absence of suitable trees or shrubs. Nest site characteristics are also highly variable. Will use wide array of coniferous and deciduous trees, shrubs, vines, human-made structures, and ground. In Utah, nests are commonly found in conifers, cottonwoods, salt cedar, orchards, grapevines, and on the ground.

### *HORNED LARK*

Horned Larks are year-round residents of the Salt Lake Region, and in fact much of the lower 48 states. Breeding season begins with nest construction, which occurs from mid-March to late June. Eggs are laid from late March until early July, and two or more broods per breeding season are common. Generally horned larks prefer bare ground for nesting, such as plowed or fall-planted fields. Nests consist of a cavity worked into the ground and lined with fine grasses. Often a nest will be surrounded by "pavings", which consist of such things as corncobs, pebbles, and cow dung. Most nests are built next to some type of protective cover, such as a tuft of grass or rock.

### *CLIFF SWALLOW*

The Cliff Swallow is one of the most social landbirds of North America. These birds typically nest in large colonies, and a single site may contain up to 3,500 active nests. Nest building tends to occur in April and May, with the height of egg-laying falling in May and June. Second broods in a season are rare; most later broods are the result of an earlier nest failure. Birds choose a colony site first, and then hone in on a particular nest site. Nests are round mud structures with a tube-shaped entrance, adhered to a vertical structure, such as a cliff, rock ledge, bridge, culvert, or building. At LNP, there is a colony of cliff and barn swallows nesting in and on the "swallow barn". Nests are typically built in a corner where there is a 90-degree juncture between a vertical wall and a horizontal overhang. Cliff Swallows prefer a nest site near or over water.

### *BARN SWALLOW*

The Barn Swallow is the most widely distributed and abundant swallow in the world. Originally nesting primarily in caves, the Barn Swallow has almost completely converted to breeding under the eaves of or inside artificial structures such as buildings and bridges. Barn swallows will nest both solitarily and colonially. Nest construction can take place anywhere from mid-April to mid-July, with the majority of egg-laying taking place from the end of April through early August. Second clutches are common. Nests are a half-cup constructed of mud and dead grasses, adhered to the sides of cliffs, buildings, bridges, and other human structures, usually under an overhang to protect from rain and weather. Swallows will often select a nest site that is close to ample food resources, such as ponds or waterways that support large amounts of mosquitoes and other

insects. At LNP, the majority of nesting barn swallows use the "swallow barn" as their nesting site, along with Cliff Swallows.

### *BLACK-BILLED MAGPIE*

Black-billed Magpies are year-round residents of the Salt Lake Region, and nest building for this species begins as early as January or February. Nest building can take as 43 days on average however, and thus egg laying and nesting do not commence until late March to early June. Magpies will lay only one clutch per season if that clutch is successful. If the nest is destroyed during the egg-laying period, they may attempt to nest again, but never attempt a second brood if the nest is destroyed after the eggs have hatched. Nest locations vary highly, but pairs may take a liking to one particular location and build nests at the same sight over several seasons. Magpies seem to prefer nesting in conifers, but will also readily nest in Russian olive (*Elaeagnus angustifolia*) and other deciduous trees, shrubs, and a variety of suburban sites. Nests are durable, domed structures built by both the male and female.

### *COMMON RAVEN*

The Common Raven is also a year-round resident of the Salt-Lake region, and nest building or repairing of an old nest site can begin as early as January or as late as mid-April. Laying begins anytime between mid-Feb and late May, although most clutches are begun in March or early April. Cold winters may delay breeding by a couple of weeks. Ravens do not have second broods unless the first nest attempt fails. Ravens nest in many microhabitats including cliffs, rock quarries, woodlots, isolated trees, rural and urban areas, along heavily traveled highways, and in remote wilderness—almost anywhere there are sufficient food resources and adequate substrate. In Legacy Nature Preserve, there is a Common Raven nest on a power pole, and another within the swallow barn (previously a Barn Owl nest, taken over by ravens). Typically nests in or on cliffs and trees, but also power-line towers, telephone poles, billboards, bridges, railroad trestles, oil derricks, windmills, communication towers, and abandoned buildings. Nest sites are often used in consecutive or sequential years for many years.

### *MARSH WREN*

Nesting season for Marsh Wrens in Utah typically begins in early April, though it can begin as early as late March and is variable from year to year. Peak of egg laying is from May until June. Females may renest after disturbance or depredation of an earlier nest, but if the first brood is successful it is typically the only brood that female will have, as the breeding cycle for female Marsh Wrens is about 6 weeks. Nest selection appears to vary among populations and perhaps with season and individual. Males build numerous nests, and a prospective mate typically inspects those nests while being escorted by the resident male. She often accepts 1 of his nests, though females may also initiate a new nest. Females often steal lining material from other females that are further along in the nesting cycle. Nests are preferentially placed in cattails (*Typha* spp.) and less commonly in bulrushes (*Schoenoplectus* spp.). Nests are typically 75-95 cm above sediment or water, and consist of a cup of interwoven vegetation with a dome covering the top. Nests are not re-used from year to year.

### *AMERICAN ROBIN*

While American Robins are year-round residents of the Salt Lake Region, nesting season for can start as early as mid-April and continues through mid-July. Peak egg laying occurs from mid-May to early July. Robins regularly raise two broods in one season. Third nest attempts are possible, but usually follow the failure of an earlier nest resulting from depredation or destruction. Nests built earlier in the season tend to be in lower and in coniferous or evergreen trees or shrubs that provide concealment; while later nests tend to be higher and in deciduous trees following growth of foliage for cover. Nests can be nearly on the ground to high up in the tree canopy, provided that there is shelter from rain provided by a layer of foliage or other means. Robins will nest in a wide variety of trees and shrubs. Robins may reuse old nests, or may build a new nest on top of the remains of an old one. More commonly however, Robins will build an entirely new nest for a new brood.

### *SAVANNAH SPARROW*

Adults arrive in April, with males arriving a week or more before females to establish territories. Females that arrive earlier than others often have more than one successful clutch per breeding season. Renesting is common following disturbance or depredation, and females have been recorded as having up to 4 clutches in one season. Most egg laying occurs in late May, and late June for second clutches. Nests placed on the ground and well hidden. Population density may not be limited by nest sites or materials. Preferred sites include shallow depressions formed by birds in grass clumps or occurring naturally in the ground amidst goldenrods (*Solidago spp*.) or at the base of low woody shrubs such as blueberry, raspberry or blackberry (*Rubus* spp.), wild rose (*Rosa virginica*), bayberry (*Myrica pensylvanica*). Most nests concealed by a canopy of dead grasses and herbs, or tucked under a tussock with a tunnel averaging 5.3 cm in length. Nevertheless, nests may be simple open cups, especially when hidden beneath shrubs, goldenrods, or other thick vegetation late in the season, or built by inexperienced yearling females. Nests generally located in open habitats but sometimes as close as 3 m to coniferous forest. Nests are almost never reused, even when a second clutch is laid in the same season.

### *SONG SPARROW*

Song Sparrows begin nest building in early April, and may begin and then abandon the first one or two nest-building attempts, often due interruptions by inclement weather. Egg-laying tends to begin in mid-April and extends through the first part of May. Multiple broods are common, resulting from depredation, though some females may have a second brood following their first successful brood. Females may even begin nest building for a second brood before the fledglings of the first brood are independent of parental care. Chief requisites for nest site selection include secure support and concealment. Support for nest is often provided by ground or vegetation. Concealment from predators and weather is usually provided by dense overhead vegetation. Nest site selection is not restricted to particular plant species; Song Sparrows may nest close to houses, often in flower beds. Specific nest site characteristics are variable; most commonly nests are low in grass and shrubs. Nests are most often found on the ground under grass tuft or shrub, but can also be located in sedge (*Carex* spp.), cattail (*Typha* spp.), some trees; locations over water are common, but rarely in tree cavities, hollow logs, rails, woodshed, or nest boxes.

### *WESTERN MEADOWLARK*

Meadowlarks can be found year-round in Utah. Breeding occurs from late March through August. Nesting occurs from April through July. Successful 1st nestings are always followed by the construction of 2nd nest. Unsuccessful females make repeated attempts at renesting over the course of the breeding season. Nests are located in pasture, prairie, or other grassland habitat; rarely in cultivated fields. Nests are well concealed, on the ground, often in shallow depressions and usually in fairly dense vegetation. Nests are often partially arched or roofed, with conspicuous runways. Construction is variable, from completely open nests without runways to nests with complete roofs and elaborate entrance tunnels, sometimes several feet long. Meadowlarks do not nest colonially.

### *YELLOW-HEADED BLACKBIRD*

Similar to the Red-winged Blackbird, male Yellow-headed Blackbirds arrive on breeding grounds in early spring (generally in mid to late March) to establish territories. Females arrive approximately two or more weeks later and select nesting sites within a male's territory. Males tend to have several females in their territory. Peak nesting is from mid-May to mid-June, with the later often being second nest attempts after a failed first attempt. Females do not commonly raise second broods but may renest if their first nest is destroyed. Nests are open-cupped, and built only over water -- fixed to dead emergent vegetation from the previous year or fixed to robust growing vegetation. Most nests are attached to cattails, bulrushes, and reeds but may also be built in willows (*Salix* spp.) or tamarisk (*Tamarix gallica)*. If the initial nest fails, the female nearly always constructs a new nest at a new location if attempting a second clutch.

### *RED-WINGED BLACKBIRD*

Males typically begin defending territories around mid-March, with females selecting males 2-3 weeks later. Nest building can begin as early as the first part of April, and continues through May. Second clutches are possible, and often follow a disturbance event such as nest depredation. Males typically have several females within their territory; with 2-3 females per male being average. Females perform the majority of nest building and all incubation, while males defend territories and alert females of predators and threats. Nest site selection is highly variable, and ranges from cattail, rush, and sedge marshes to upland meadows, old fields, and agricultural substrates. While nests are typically built in grasses on or just above the ground, some birds select nest sites higher up, often in willows or other wet meadow tree species. Nests are not re-used within or between seasons.

### *HOUSE FINCH*

The House Finch is another year-round resident of Utah, and is a common and familiar bird in suburban neighborhoods as well as in open and semi-open habitats throughout the West. Throughout most of its range, nest building begins in mid- to late March and can last through late July. Most females nest more than once, and regularly have 2 or 3 successful broods per breeding season. Males will often care for fledglings at the end of the first clutch, while the female begins nest building and laying a second clutch. Nest habitat varies widely, but favors open or semi-open habitats; particularly those with artificial structures or presence of conifers for actual nest sites. A wide variety of nest sites are chosen as well; including pine or spruce trees, rock ledges, vents, ledges, or ivy on buildings, street lamps, hanging planters, and abandoned nests of other

birds. Rarely, House Finches will use broad-leaf deciduous trees or cavities for nesting. The main requirements appear to be a solid base with some overhanging structure. Finches may or may not use the same nest for subsequent broods; more often it seems that a female will build at a new site when renesting.

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# APPENDIX B. BALD EAGLE NEST RESTRICTIONS

As a requirement of the Army Corps of Engineers (ACOE) Section 404 Permit and the US Fish and Wildlife Service (FWS), certain restrictive actions must be taken to protect the nesting Bald Eagles at LNP. No unauthorized human access within 1 mile of the bald eagle nest will occur during courtship, breeding, or nesting periods, from January 1 through May 21. Any required maintenance activities on LNP that fall within the 1-mile buffer must be minimal and follow the guidelines provided by the FWS). From May 21 to August 31, no unauthorized human access will occur within 0.5 miles of the nest. A similar 0.5-mile buffer is required around all known bald eagle winter roosting sites on and surrounding LNP, from November 1 to March 31. Exceptions may occur on a case-by-case basis following approval from the FWS.

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# APPENDIX C. NOXIOUS AND INVASIVE INTEGRATED WEED MANAGEMENT PLAN

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# 1.0 INTRODUCTION

This plan summarizes weed management concerns and identifies control methods for selected Management Areas (MAs), to be administered by the Utah Department of Transportation (UDOT) in fulfilling a U.S. Army Corps of Engineers (USACE) mandate to develop the Legacy Nature Preserve (LNP). This plan emphasizes an Integrated Pest Management approach, which considers all site conditions and prescribes cultural, mechanical, biological, and chemical weed management practices. In this approach, the objectives for land management are to control weed establishment, while concurrently preventing soil disturbance and erosion, reducing risks to native flora and fauna, and maintaining natural ecosystem function. Specific noxious weed species and control measures are identified in this plan, as is a systematic method of setting treatment area priorities with measurable control objectives.

## 1.1 ADAPTIVE MANAGEMENT STRATEGY

Adaptive management is a "holistic" means of addressing the complex and numerous problems that noxious weeds pose to landowners and land managers. An adaptive management strategy considers weed management as an ongoing process, where the outcome of control efforts may vary and necessitate various methods for prevention and suppression. The Colorado Natural Areas Program (2000) has outlined six steps in an adaptive management process, which will be useful for management of weeds on LNP property. These steps were used as a framework for this Weed Management Plan:

1. Describe the property
2. Inventory the property for weeds
3. Formulate weed management goals and objectives.
4. Set priorities for management areas and weed species.
5. Select integrated weed management strategies
6. Develop a monitoring and evaluation plan

### 1.1.1 Integrated Weed Management

An important component of adaptive management is an integrated weed management plan as described in this State of Colorado Handbook (2000).

> No single management technique is perfect for all weed control situations and multiple management actions are required for effective control. The strategy of using an integrated selection of management techniques has been developed for use in a variety of “pest” control situations, including plant pests, or weeds. Integrated Weed Management (IWM) is a process by which one selects and applies a combination of management techniques (biological, chemical, mechanical, and cultural) that, together, will control a particular weed species or infestation efficiently and effectively, with minimal adverse impacts to non-target organisms. Ideally, these management techniques should be selected and applied

> within the context of a complete natural resource management plan. Most traditional weed management concentrates only on suppression which treats the symptoms of weed infestation, typically by using herbicides to kill weeds. IWM differs from ordinary weed management in attempting to address the ultimate causes of weed infestation, rather than simply focusing on controlling weeds. Although focusing on the fundamental causes of weed invasion and persistence is more demanding than simply spraying weeds, the rewards are far greater and are worth the effort. Over the long run, IWM should lead to greater success in meeting management objectives. IWM is "predicated on ecological principles and integrates multidisciplinary methodologies in developing ecosystem management strategies that are practical, economical and protective of public and environmental health" (Piper 1991). IWM seeks to combine two or more control actions which will interact to provide better control than any one of the actions might provide. However, even if multiple control actions do not interact, their additive effects can mean the difference between success and failure. In addition, employing multiple control actions should increase the likelihood that at least one of them will control the target weed species. IWM is species-specific, tailored to exploit the weaknesses of a particular weed species, site specific, and designed to be practical with minimal risk to the organisms and their habitats.

As LNP works through the adaptive management process and considers implementing its own weed management plan, it should consider these general principles of Integrated Weed Management.

1. Work to establish and maintain functioning native communities- Disturbance both anthropogenic and natural is the primary factor that leads to the degradation of native plant communities and the spread of noxious weeds.
2. Implement appropriate prevention methods- In addition to appropriate land use management, preventing weeds from invading a site in the first place is the most effective and least costly method for controlling weeds.
3. Choose appropriate control actions- Selecting a control strategy is a function of the biology and ecology of the target species. The appropriate action should also be
    a. applied at the most effective time;
    b. least damaging to non-target organisms;
    c. least hazardous to human health;
    d. least damaging to the general environment;
    e. most likely to reduce the need for weed control over the long term;
    f. most easily implemented;
    g. most cost effective in the short and long term.

The following is an example of IWM for a target species taken from the State of Colorado (2000) Handbook for creating an integrated weed management plan.

> Perennial pepperweed (also known as tall whitetop) is a long-lived, rhizomatous perennial that produces prolific tall, bushy sprouts from a large root system. It is frequently found in croplands, riparian areas and wetlands. It can be controlled by

first removing standing dead stems from previous years at the flower bud growth stage, followed by application of chlorsulfuron herbicide. Removal of the standing dead material can be accomplished by mowing or by "chemical fallowing" with 2,4-D. Mowing twice is the recommended approach because it is more effective than a single mow or chemical fallow. The mowing or fallowing apparently changes the leaf architecture of the pepperweed, thereby greatly increasing the amount of herbicide that falls on the leaves and, later, is translocated to the roots. Changes in leaf architecture and removal of standing dead material as a result of mowing may also increase herbicide effectiveness in other weed species such as Canada thistle. Follow up by re-seeding the treated areas with a mixture of competitive, desirable grass species.

## 1.2 THE ECOLOGY OF PLANT COMMUNITY COMPOSITION

Many weed control efforts target and treat symptoms, rather than explore and reduce the causes of the weed infestations. A successful native ecosystem restoration plan recognizes what mechanisms drive certain plant species to thrive in specific environments, and determines if that driver can be used to restore desirable plant communities, or if it needs to be reduced or eliminated before restoration objectives can be met. In order to manage succession, we need a thorough understanding of its cause, the processes that drive species composition, and the modifying factors that can or cannot be controlled.

Oftentimes, anthropogenic disturbances create conditions that favor non-native, invasive plant species. The successful establishment of non-native, invasive plant species is often due to high reproductive rates, rapid root growth, lack of natural predators, and/or a superior ability to utilize limited resources (Mack et al. 2000; Sperry et al. 2006, Coombs et al 2004). The result is that native plant species are unable to compete. These factors can result in a shift in the vegetation community towards dominance of exotic, invasive plant species (Mack et al. 2000). This scenario has been observed in various disturbed habitats on LNP lands.

Contributing factors to the current weed dominated plant communities on LNP property include surface disturbance and vegetation removal associated with mining, fire, grazing, flooding, avalanche, drought, and air pollution. The size and severity of various disturbances are determined by modifying factors such as predisturbance history, time intervals between disturbances in a given area, and patchiness and uneven intensity of the disturbance. The species composition in a plant community is a product of not only disturbance history but also the availability of native and weedy plant seeds to establish following a disturbance. Dispersal mechanisms and landscape features affect seed dispersal, and propagules can be hindered by land use, disturbance intervals, and species life history (Sheley and Mangold 2005).

Individual plant species performance is based on numerous factors. Resources, such as soil, topography, climate, site history, microbes, and litter retention are abiotic factors that define the physical conditions to which a specific plant may be adapted, such as alpine or wetland species. Specific ecophysiological characteristics will also dictate the success of individual plants, including germination requirements, assimilation rates, growth rates, and genetic differentiation. Life history traits such as root allocation, reproduction timing, and number of offspring

contribute to the competitive ability of plant species. The manner in which a plant controls stress from climate shifts, herbivory, natural enemies, competition, allelopathy, and resource availability in combination with the abiotic factors will ultimately dictate the final species composition in a given plant community.

## 1.3 MANAGING PLANT COMMUNITY COMPOSITION

One approach to adaptive or ecologically based invasive plant management is to create weed resistant plant communities using desirable, and preferably native, plant species (Sheley and Mangold 2005). The factors that drive desirable plant communities toward weedy infestations include disturbance, colonization, and species performance. Managing the drivers to change the current plant community dominated by weeds to a plant community dominated by a variety of native species should involve the same factors. Therefore, we must choose a disturbance in conjunction with specific controlled colonization mechanisms that will eliminate or reduce the current vegetation community and provide a colonization strategy for the native plant species. Finally, it is important to identify species that will compete to obtain a desired final plant community, and select factors that may be enhanced by abiotic intervention, such as fertilization, mowing, or soil alterations.

Once a plant community is established, such as a stand of hoary cress, it will require a disturbance to the system to change from the stable yet undesirable state to a desirable, weed-free state. This disturbance needs to be chosen carefully to achieve the desired effect. For example, grazing hoary cress stands removes the above ground biomass, which stress the individual plants. Individual plants respond by reallocating root resources to restore the lost photosynthetic tissue. Above ground biomass removal will deplete the root reserves kill the plants, but it will likely take up to three consecutive years of aggressive grazing to completely deplete root reserves. However, in the case of hoary cress, the toxicity associated with the leaves may eliminate grazing as a viable option. Even if toxicity is not considered, the cost and logistic difficulties associated with the repeated treatments necessary to deplete root reserves are often prohibitive. Therefore, another disturbance option, or combination of disturbances, may be more appropriate for hoary cress stands, such as mowing and herbicide application. The optimal time to spray hoary cress is in May or June during the bud or flowering stage before the seeds have set. Hoary cress develops at different rates within a community depending upon micro topographical changes in the landscape. South facing hillsides or depressions will flower first, and may set seed by the time the surrounding community flowers. Therefore, multiple sprayings may be required to assure that all hoary cress individuals are sprayed before setting seed. Another option would be to mow the hoary cress population to eliminate current budding individuals. Hoary cress will then resprout and flower simultaneously across the population allowing for a systematic herbicide treatment at the appropriate time. Herbicide choices for broad-leaved plants that do not affect grasses include dicamba, picloram, and 2,4-D.

It is imperative to continue to incorporate the processes that drive the system toward a desirable state by ensuring sufficient seed is available for colonization. Because of the extensive root system, several years of herbicide application may be required to contain the hoary cress infestations. Therefore, broadcast seeding with desirable grass species that won't be affected by

continued broad-leaf herbicides would supply the area with early succession plants species to begin competitive interactions with hoary cress. These include Indian ricegrass (*Achnatherum hymenoides*), squirreltail (*Elymus elymoides*), and blue bunch wheatgrass (*Pseudoroegneria spicata*). As the hoary cress infestation is diminished, additional shrub species that would otherwise be affected by herbicides can then be introduced, such as antelope bitterbrush (*Purshia tridentata*) and big sagebrush (*Artemisia tridentata*). The species chosen need to be selected based on their ability to survive in a particular environment. Continued maintenance and monitoring for several years will be necessary to identify problems such as new weed infestations, lack of vigor in the restored, native community, and additional site amendment requirements such as fertilizer/topsoil or irrigation. Further examination of specific control prescriptions will be detailed in the habitat account section (Section 5.0 Weed Control for Management Areas).

## 1.4 CHALLENGES

Numerous challenges were encountered during the development of this weed plan, which included survey work. The mapping effort in the spring of 2006 identified numerous Utah State-listed noxious weeds, as well as non-listed weedy species, whose presence may influence the overall habitat goals of the LNP. Populations of weeds were visibly expanding during the several months of mapping, therefore the actual areas of weed infestation found throughout this document are conservative estimates.

Because of the wetland habitats throughout the LNP and the movement of water throughout the floodplain, chemical herbicides are discouraged in many places so they do not enter water sources; for the same reason, herbicides are less effective in wet areas, as they often do not stick to the target plants. The presence of many wetland habitats, including inundated areas, also presents the challenge of preventing the water transport of seeds and pollen of undesired species.

A nesting pair of bald eagles resides in the southern end of the LNP, in the Riverine MA. A 0.25-mile buffer around the nest prohibits entry into this area to either map the extent of weeds or allow treatment of weeds in this area during the nesting and fledgling time periods. Further consultation with the USFWS is necessary to develop options to access this area, and may include allowing goats into this area without herders or dogs, and seeding with competitive desirable plant species to compete against the weed species.

This plan seeks to identify management controls that will be effective in combating the noxious weeds on the LNP, while maintaining and enhancing the native habitat for wildlife and shorebirds.

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# 2.0 PROPERTY DESCRIPTION

## 2.1 BACKGROUND

As a result of growth and land use practices along the Wasatch Front, wetland habitat on the eastern shore of Great Salt Lake has been disturbed, and the natural flow of water from the Wasatch Mountains has been interrupted. The LNP, a small but integral part of the Great Salt Lake ecosystem, is adjacent to the southeast shore of Great Salt Lake. The LNP provides foraging, nesting, and staging habitat for millions of migratory birds from the western hemisphere and supports hundreds of species of plants and wildlife. The nearly 2,100-acre LNP contains a variety of wetland complexes, riparian habitats, and uplands, 900 acres of which are some type of wetland or riparian habitat. The remaining 1,200 acres consist of upland desert salt scrub and grasslands (SWCA 2006).

The primary mitigation objectives associated with the Section 404 permit issued to UDOT by the USACE in association with the Legacy Parkway are to:

- preserve wetlands and supporting upland areas for wildlife habitats that are threatened by development,
- restore the hydrology to the area, including a hydrologic link between the Jordan River and its floodplain,
- enhance mitigation habitats for increased biological production by removing human impacts and disturbances, and
- create slope wetlands with artesian wells (USACE 2005).

Restoration and enhancement of wetland functions that have been damaged as a result of past land-use activities will improve the existing wetland functions of the LNP and the overall health of its wetland habitat.

The areas reserved for mitigation have been subjected to years of human disturbance that have caused extensive hydrologic alterations to, and degradation of, wetland and upland habitats. Agricultural practices in the area have resulted in vegetation shifts from native species to areas dominated by cultivated forage grasses, such as intermediate wheatgrass (*Thinopyrum intermedium*) (SWCA 2006). Grazing may have helped to limit invasive species in abundance and to particular locations; however, as cattle and crops were removed from the area following a change in land ownership to UDOT, invasive weed species have flourished. The most common weed species currently found on the LNP include hoary cress (*Cardaria draba*), perennial pepperweed (*Lepidium latifolium*), field bindweed (*Convolvulus arvensis*), Scotch thistle (*Onopordum acanthium*), purple loosestrife (*Lythrum salicaria*), dyer's woad (*Isatis tinctoria*), poison hemlock (*Conium maculatum*), Russian olive (*Elaeagnus angustifolia*), tamarisk (*Tamarix ramosissima*), dalmation toadflax (*Linaria genistifolia*), and phragmites (*Phragmites australis*; SWCA 2006).

## 2.2 UTAH WEED REGULATORY GUIDANCE

Laws and regulations concerning noxious weeds exist at both the federal and state levels, and numerous federal and state agencies maintain lists of specific noxious weed species that must be controlled. Generally, federal weed laws and regulations are geared toward preventing unwanted plants from entering the U.S., while state laws and regulations are aimed more at the control and removal of noxious weeds (EPA 2006).

In recognition of the economic and ecological impacts of weeds, the State of Utah adopted the Utah Noxious Weed Act (Utah Code, Title 04, Chapter 17), which was recently updated on June 15, 2006. The act requires landowners and mangers to manage the state listed noxious weeds if those weeds are likely to damage neighboring lands. The act stipulates that each county and municipality in Utah must adopt a noxious weed management plan for its jurisdiction, and appoint an advisory board to develop the weed management plans and identify the plant species in its area that it considers noxious weeds. Landowners and managers are responsible for controlling the state and county listed species. If they fail to do so, the county or municipality may legally enter the property, control weeds, and charge the landowner for the cost of control work.

The State of Utah has identified 18 species as noxious weeds. Table 1 lists these species, as well as all 20 County-specific weed species. Although not listed in Salt Lake County, many of the county listed species have been observed in Salt Lake or adjacent Tooele Counties.

**Table 1. Utah State and County Noxious Weed List, 2006**

| Common Name | Scientific Name | Designation (State or County) |
|---|---|---|
| Quackgrass | *Agropyron repens* | State of Utah |
| Hoary cress | *Cardaria draba* | State of Utah |
| Musk thistle | *Carduus nutans* | State of Utah |
| Diffuse knapweed | *Centaurea diffusa* | State of Utah |
| Spotted knapweed | *Centaurea stoebe* ssp. *micranthos* | State of Utah |
| Russian knapweed | *Centaurea repens* | State of Utah |
| Yellow starthistle | *Centaurea solstitalis* | State of Utah |
| Squarrose knapweed | *Centaurea virgata* | State of Utah |
| Canada thistle | *Circium arvense* | State of Utah |
| Field bindweed | *Convolvulus arvensis* | State of Utah |
| Bermudagrass | *Cynodon dactylon* | State of Utah |
| Leafy spurge | *Euphorbia esula* | State of Utah |
| Dyer's woad | *Isatis tinctoria* | State of Utah |
| Perennial pepperweed | *Lepidium latifolium* | State of Utah |
| Purple loosestrife | *Lythrum salicaria* | State of Utah |
| Scotch thistle | *Onopordum acanthium* | State of Utah |
| Johnsongrass | *Sorghum halepense* | State of Utah |

**Table 1. Utah State and County Noxious Weed List, 2006**

| Common Name | Scientific Name | Designation (State or County) |
|---|---|---|
| Medusahead | *Taeniatherum caput-medusae* | State of Utah |
| Velvetleaf | *Abutilon theophrasti* | Sanpete |
| Jointed goatgrass | *Aegilops cylindrical* | Tooele and San Juan |
| Camelthorn | *Alhagi psuedalhagi* | San Juan |
| Common burdock | *Arctium minus* | Morgan |
| Western whorled milkweed | *Asclepias subverticillata* | Washington, San Juan |
| Bull thistle | *Cirsium vulgare* | Beaver |
| Poison hemlock | *Conium maculatum* | Cache, Rich, Davis |
| Houndstongue | *Cynoglossum officinale* | Tooele, Wasatch, Sanpete |
| Yellow nutsedge | *Cyperus esculentus* | Davis |
| Russian olive | *Elaeagnus angustifolia* | Duchesne, Uintah, Carbon, Sevier, Wayne |
| Goatsrue | *Galega officinalis* | Cache |
| Black henbane | *Hyoscyamus niger* | Rich, Sanpete |
| St. Johnswort | *Hypericum perforatum* | Box Elder |
| Blue lettuce | *Lactuca pulchella* | Juab |
| Dalmatian toadflax | *Linaria dalmatica* | Tooele, Rich, Wasatch |
| Yellow toadflax | *Linaria vulgaris* | Tooele, Wasatch |
| Silverleaf nightshade | *Solanum elaeagnifolium* | Washington, San Juan |
| Buffalobur | *Solanum rostratum* | Davis, Millard, San Juan |
| Tamarisk | *Tamarix ramosissima* | Uintah |
| Puncturevine | *Tribulus terrestris* | Cache, Weber, Morgan |

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# 3.0 PROPERTY MAPPING AND INVENTORY

## 3.1 WEED MAPPING OBJECTIVES

The primary objective of surveying and mapping is to accurately delineate the weed infestations, and to identify land that is threatened by noxious and invasive weed encroachment. Mapping is done not only to establish a historical database, but also to develop weed management goals and objectives; increase public awareness; and evaluate weed management progress as it relates to noxious weed spread rates and patterns. For this project, high priority weed infestations should be mapped and evaluated to determine the most appropriate treatment method for each. Mapping should include recording the size, density and composition of weed infestations. This information can then be used to determine the treatment type necessary for each weedy infestation as well as provide a baseline for future monitoring efforts.

Weed survey information is collected and compiled into maps showing the distribution and severity of infestations. Weed monitoring involves repetitive surveys to track weed populations over time. A standardized system of weed surveying and mapping is necessary to provide consistently reliable information that can be compared from year to year. Further, a standardized system allows weed survey data to be incorporated into a statewide weed survey database for the production of statewide noxious weed maps.

## 3.2 WEED MAPPING METHODS

Weed survey maps may be created by hand-drawing infestation boundaries on aerial or topographic maps or, by collecting location coordinates of weed infestations using Global Positioning System (GPS) technology. Location information is then digitized using ArcView. Information can be obtained by including weed reporting information from LNP personnel that includes the species identification, size of infestation, relative cover, and location using UTM coordinates when possible. Aerial photographs show good detail and can be used to locate positions while in the field and draw in surveyed weed infestations. Satellite imagery does not have high enough resolution to be used for weed mapping. Satellite imagery with high spatial resolution will probably be available at a reasonable cost sometime in the next five to ten years (MSU 2006).

Weed mapping at LNP property is necessary to adequately determine the most cost effective and efficient implementation practices. Because individual weed species respond differently to control treatments (biological, chemical, and mechanical), it is necessary to evaluate the species present in an infested population, the size of the infestation, and additional parameters that may influence management decisions (visibility, dust control, fire hazards). Furthermore, wildlife and riparian habitat requirements may influence treatment control decisions. This plan provides a series of options that will help make those weed management decisions once mapping has been completed.

## 3.3 NOXIOUS WEED SPECIES ACCOUNTS

All of the Utah State and Salt Lake and Davis County listed noxious weeds, as well as invasive weeds that are a concern to ecosystem health has been described below. Information regarding effective biological and/or chemical control is also included. Information on the species descriptions was largely obtained from the Utah State University Noxious Weed Field Guide for Utah (Belliston et al. 2004).

### 3.3.1 State-Listed Noxious Weed Species

#### 3.3.1.1 RUSSIAN KNAPWEED (*ACROPTILON REPENS*)

**Background**: Russian knapweed is native to Eurasia, and was probably introduced to North America as a contaminant in crop seed. It is listed as a noxious weed in Utah, Nevada, Wyoming, Colorado and several other states. It infests rangelands, field edges, pastures, roadsides, and other disturbed soils. It can release chemical substances into the soil that inhibit the growth of competing vegetation creating dense monotypic stands. It can cause chewing disease in horses that consume it, and tumors on the hands of workers that pull it without protective equipment. It is not restricted to any particular soil but does especially well in clay soil (Belliston et al. 2004).

**Description**: Russian knapweed can be distinguished from other knapweeds by the pointed papery tips of the floral bracts. The flower heads of Russian knapweed are urn-shaped, solitary, and composed of disk flowers only with pink or purple petals. Leaves are alternate and lance shaped, and lower leaves are deeply lobed becoming progressively smaller and less lobed toward the top of the plant. It spreads primarily by creeping horizontal roots, and does not appear to reproduce extensively from seed, although seeds can remain viable in the soil for 2 to 8 years. Shoots emerge early in spring shortly after soil temperatures remain above freezing; shoot development originates from root-borne stem buds. These buds arise adventitiously at irregular intervals along the horizontal roots. Vertical roots can reach 8 feet or more in depth. Plants form rosettes and bolt in late May to mid-June; once plants bolt there are no buds capable of flowering until fall, thereby removing flowering tissue will effectively reduce seed production. Russian knapweed flowers from June to October (CSU 2000, Belliston et al. 2004).

**Control**: Only the gall-inducing nematode *Subanguina picridis* has been introduced and established in North America. Although the nematode is effective in reducing plant biomass and flowering, infections are not consistent from year to year due to varying moisture conditions. The nematode does not move readily, thus it needs to be propagated and redistributed on a large scale, which is not cost effective with present techniques. For these reasons, other organisms are being considered for biological control. The seed head weevil *Eustenopus villosus*, a biological control agent of yellow starthistle, occasionally feeds on seed heads and causes them to abort.

Three fungi have been found on Russian knapweed, *Alternaria* sp. and *Puccinia acroptili* that attack the leaves, and *Sclerotinia sclerotiorum* which infects the roots (Coombs et al. 2004).

Grazing the above ground portion of the plant reduces the current year growth, and may eliminate seed production, but it will not kill Russian knapweed. Goats prefer the flowering heads, but will occasionally graze green tissue (Lamming 2001). Removing aboveground biomass several times before the plants bolt stresses Russian knapweed plants and forces them to use nutrient reserves stored in the root system. The plants that re-emerge are usually smaller in size and lower in vigor. Once plants have bolted, there are no more buds capable of flowering, until buds begin to form again in mid-August to September (CSU 2000).

A combination of mowing/grazing and herbicides are effective against Russian knapweed. Mowing/grazing immediately prior to applying picloram at 1 quart per acre and clopyralid at one pint per acre in the fall allows the herbicide to reach the intended target, the soil surface. Rains carry the herbicide into the root zone, where the plant roots take it up the following spring to prevent future weeds (Carpinelli et al. 2004). Using a combination of clopyralid and 2,4-D can decrease Russian knapweed biomass when applied at flowering, and was still effective two years after application. Applying 2,4-D plus clopyralid at the rosette or flowerbud to flowering stage did provide some control, but not as effective as when applied to the flowering stage. Additionally, desirable grass species are unaffected, and increased in density and biomass following 2,4-D plus clopyralid application (Laufenberg et al. 2005). Apply 1 ounce per acre chlorsulfuron or 0.75 to 1 ounce per acre metsulfuron when Russian knapweed is in the bloom to postbloom stage. Earlier applications do not control the weed effectively. Fall is a good time to apply chlorsulfuron and metsulfuron. Always add a good agricultural surfactant at 0.25 to 0.5 percent v/v to the spray solution (CSU 2006).

Picloram may persist for several years in the soil, and can cause eye and liver damage to mammals as well as targeting desirable plant species. Clopyralid can persist in the soil for up to 14 months targeting desirable plant species, and can cause eye and reproductive complications to exposed mammals.

Continued monitoring for new infestations is critical, and spot spraying may be necessary. The seeds remain viable for two to eight years, and herbicide application may need to be repeated annually for several years to exhaust the soil seed bank (CSU 2000).

Seeding with desirable grass species that will compete for resources because Russian knapweed may be outcompeted in moister locations due to competition with perennial grasses (CSU 2000).

### 3.3.1.2 HOARY CRESS (*CARDARIA DRABA*)

**Background**: Hoary cress (whitetop) is a Utah State listed noxious weed introduced into North America from Eurasia in the late 19th century. It is now widespread throughout diverse habitats, and is classified as a noxious weed in at least 24 states (Coombs et al. 2004).

**Description**: Hoary cress germinates in the fall, over-winters as rosettes, and blooms in May. After flowering, the plant continues to grow until the first frost reaching 2 feet (0.75 m) height. Leaves are blue-green and lance shaped, with the lower leaves stalked and the upper leaves having two lobes clasping the stem. Flowers are white with four petals giving the plant a flat-topped appearance. Heart-shaped seed capsules contain two reddish-brown seeds separated by a narrow partition, and can remain viable for three years. This species reproduces not only from seed, but from rhizomes as well. Adventitious buds can develop from the lateral rhizomes with an average of 50 new buds for a total of 2 to 3 feet (1 m) growth per year per plant. Hoary cress can overtake native plants developing monocultures that degrade wildlife habitat and decrease biodiversity. It prefers wet, alkaline, open soils, and is often found with invasive bromes and knapweeds (Belliston et al. 2004). Two other *Cardaria* species, lens-podded whitetop (*C. chalepensis*) and hairy whitetop (*C. pubescens*) are common in the western U.S. with differences in seed capsules and fruit characteristics (Baldwin et al. 2002, Whitsom 1999).

**Control**: Control of hoary cress is very difficult, and eradication requires continual work and monitoring. Small controlled patches or the perimeter of large patches are the best option, followed by attacking any plants that expand beyond the containment area. Because of the extensive root system, removing new shoots is extremely important. Sheep and goats will consume hoary cress more readily than cattle. Cattle will consume hoary cress but hoary cress contains glucosinolates, which may be toxic at high levels. Moreover, hoary cress may inhibit iodine absorption in goats, but can be countered with iodine supplements. Insufficient information is currently available on the effectiveness of prescribed grazing of hoary cress. Surveys and literature disagreed on the potential of controlling hoary cress with grazing because of palatability and toxicity issues. However, repeated grazing may reduce plant vigor and flower production (USFS 2006).

Mowing or grazing alone will not provide effective long-term control of hoary cress. Hoary cress plants can survive repeated removal of top-growth for at least 1 season without noticeable loss in vigor. Two consecutive years of mowing or grazing may have a more noticeable effect; however, hoary cress plants often preserve some of their vitality even after 3 years. The date of mowing or grazing influences subsequent reproductive efforts; plants mowed or grazed during flowering produced fewer viable seeds than plants mowed during bolting. While defoliation alone is not expected to be an effective long-term control of hoary cress, properly timed above ground biomass removal followed by herbicide application may increase mortality (USFS 2006).

Where physical conditions permit, hoeing or tilling at intervals of 3 to 4 weeks (depending on rate of regrowth) may be as effective as cultivation for eradication of hoary cress. Soils must remain moist between hoeing so that plants can regenerate and deplete their root reserves. Plants must be completely removed within 10 days after emergence throughout the growing season for 2 to 4 years, therefore making this method impossible for all but the smallest patches (USFS 2006).

Hoary cress and related *Cardaria* species are most commonly controlled with herbicides. However, multiple applications are usually needed to provide lasting control. The best time to apply herbicides is in May or June, between bud and before flowering. Metsulfuron and chlorsulfuron are the most effective herbicides as long as the plants still have green tissue. It is important to use a non-ionic surfactant with the herbicide. The herbicides imazapic, 2,4-D, and glyphosate provide good to fair control when applied during the early pre-bud stage (late May through early June) (Dewey et al. 2006). Large hoary cress stands may flower at different times due to changes in micro topography; south facing slopes and depressions will flower days to weeks before south facing slopes. Once herbicide is sprayed, the flowering plants will immediately set viable seed. Therefore it is imperative to apply herbicide at the bud stage, prior to flowering. To synchronize the plants, mowing or grazing may be an option in localized areas to create a phenotypic homogenous community that can be more effectively sprayed with herbicide. It will usually take several seasons to eliminate a hoary cress patch due to both root regrowth from surviving plants as well as depleting the soil seed bank (CSU 2000).

Seeding with desirable grass species that will compete for resources but not be affected by the broad leaf herbicides is critical in the combat against hoary cress.

#### 3.3.1.3 MUSK THISTLE (*CARDUUS NUTANS*)

**Background**: Musk thistle in an invasive biennial, summer, or winter annual forb. Musk thistle populations in North America exhibit almost continuous variation in characteristics such as hairiness, leaf size, spine length, flower stalk diameter, width and shape of bracts, and corolla length. Correct identification of musk thistle is important if control strategies are planned since it can be easily confused with native thistles: some of which may be threatened or endangered, and the vast majority of which fill specific ecological niches and have traits useful to humans (USDA 2006).

**Description**: As a biennial, musk thistle initially forms a prostrate rosette. Rosette leaves can grow up to 10 inches (25 cm) long and 4 inches (10 cm) wide, and rosettes can be 2 feet (0.6 m) or more in diameter. Musk thistle rosettes have numerous small roots in the fall, and develop a large, fleshy taproot in the spring that is hollow near the soil surface. The root crown and upper root tissues contain buds, normally suppressed by apical dominance, which may sprout following damage to plants (USDA 2006).

Musk thistle may have 1 to 7 branched stems that grow 2 to 6 feet (0.6 to 2.0 m) tall. Stem leaves are 3 to 6 inches (7.6 to 15.2 cm) long, dark green with a light greed midrib, with toothed, spiny

lobes; upper leaves are much reduces. Stems have spiny wings their full lengths except for a few inches below flowerheads. Flowerheads are large, often nodding, 1.5 to 3 inches (3.8-7.6 cm) in diameter, solitary, terminal, and are entirely comprised of purple disc flowers. Numerous large, lance-shaped, spine-tipped bracts that resemble a pinecone subtend flowers, and are a very distinctive identification feature. The fruit is an achene bearing 0.13- to 0.19-inch (0.3-0.5 cm) seeds with a hair-like pappus (USDA 2006, Belliston et al. 2004).

Seed production is quite variable, and is determined by habitat conditions, size of plant at flowering, and duration of flowering. The life cycle exhibited by a particular musk thistle plant also influences seed production, with biennials producing more than winter annuals, and winter annuals producing more than summer annuals. The first flowerheads to emerge (terminal and topmost branch) are usually solitary, and are the largest and produce the most seeds. The number of seeds per inflorescence decreases over time along with inflorescence size. Musk thistle can continue to produce flowers and seeds throughout the growing season if soil moisture levels are adequate. The amount of seed produced is therefore markedly affected by spring and summer rainfall patterns. Terminal flowers average about 1,000 seeds per head, while the last ones to bloom produce about 125 seeds or fewer per head (USDA 2006). Germination of musk thistle seeds in the field occurs over several months in the fall and spring. A dormancy period could prevent seeds from germinating all at once in response to transient summer rainfall, and allow time for some seed to become buried (USDA 2006).

Wind, water, wildlife, livestock, and human activities disperse musk thistle seed. Many musk thistle seeds fail to separate from the receptacle, so fruiting heads with seeds often fall to the ground. Thus, the majority of seeds are deposited in a dense pattern near the parent plant. This may help to explain musk thistle's slow rate of spread into favorable habitats close to existing populations. Musk thistle seeds may remain viable in the soil for 10 to 15 years or more, with seeds buried in the top 2 cm of soil surviving 3 years, and seed buried at greater depths maintaining viability for longer periods (USDA 2006).

**Control**: The most widely released insect is the weevil *Rhinocyllus conicus*. In the spring, adults will feed on the leaves, mate, and deposit eggs on the bracts. When the eggs hatch the larvae begin to bore into the flowerhead reducing the ability of the plants to produce viable seed. In some cases the weevil has reduced musk thistle populations to less than 10% pre-release levels. Seedheads that are attacked by the thistlehead weevil often become tightly fixed, and although they may still germinate, competition among germinating seeds will cause high rates of intraspecific mortality. However, this weevil will also attack native thistles, including rare species (CSU 2000).

Repeated mowing, hand pulling, or grazing can be used to stop the spread of musk thistle. Mowing or grazing after flowering but before seed set prevents seed development and dispersal. Musk thistle appears to be a favorite of older male goats (Lamming 2001). When pulling musk thistle it is important to completely remove the crown so that the plant does not simply re-bolt and produce seeds. Repeated visits at weekly intervals over the 4 to 7 week flowering period is necessary when removing aboveground biomass because not all plants flower at the same time. Cut plants should be deeply buried or burned because seeds can mature and become viable after cutting.

Musk thistle is most often controlled with herbicides, and can be combined with Scotch thistle treatments. The most effective chemical control occurs when musk thistle is still in the rosette stage, and quickly decreases once the plant has bolted. Picloram and metsulfuron offer excellent control when applied at 10-16 oz per acre and 0.5 to 1., oz per acre respectively. Apply both herbicides to rosettes; fall is optimal although spring applications are also effective. Clopyralid at 0.66 pt per acre, chlorsulfuron at 0.5 to 1.0 oz for musk thistle and 1 to 3 oz per acre for Scotch thistle, and a combination of clopyralid and 2,4-D (Curtail®) at 1 to 2 qt per acre provide good control when applied from the late rosette stage to early bolting. Seeding with desirable grass species that will compete for resources but not be affected by the broad leaf herbicides is critical.

#### 3.3.1.4 DIFFUSE KNAPWEED (*CENTAUREA DIFFUSA*)

**Background**: This short-lived perennial forb was introduced from Eurasia, where it grows in the eastern Mediterranean area and in western Asia to western Germany. It is a pioneer species that can quickly invade disturbed and undisturbed grasslands, shrublands, and riparian communities. Like most knapweeds, diffuse knapweed exudes chemical substances into the soil that inhibit the growth of competing vegetation. Diffuse knapweed is found on plains, rangelands, and forested benchlands. It is generally found on light, dry, porous soils. Diffuse knapweed has been observed at elevations up to 8,500 feet (2,591 m), and grows in open habitats as well as shaded areas (CSU 2000).

**Description**: Diffuse knapweed is an annual or a short lived perennial from 1 to 2 feet (0.6 to 0.6 m) tall. The flower heads are broadly urn-shaped, less than 1 inch (2.5 cm) tall, and can be either solitary or in clusters of 2 to 3 at the ends of branches. The heads contain two types of flowers, ray flowers around the edges surrounding tubular disk flowers that bloom throughout the summer; flowers are white, rose-purple, or lavender. Diffuse knapweed differs from other knapweeds in that the toothed flower bracts are straight and end as sharp, rigid spines rather than arched outward. Basal leaves are stalked and divided into narrow, hairy segments. Stem leaves are smaller, alternate, less divided, stalkless, and become bract-like near the flower clusters. Seedlings have finely divided leaves that are covered with short hairs (Belliston et al. 2004).

Reproduction is primarily by seed; it first forms low rosettes that may remain in this form for one to several years, depending on environmental conditions. When the rosette reaches a critical size, it bolts, flowers, and usually dies. Flower buds are formed in early June and flowering occurs in July and August. Mature seeds are formed by mid-August. Seed dispersal is primarily by wind, but can be lodged under vehicles or in animal hooves thereby expanding their long distance dispersal (Belliston et al. 2004).

**Control**: Currently, biological control agents are available but the extent to which they effectively control diffuse knapweed populations is unclear. A combination of several insects may be required to control diffuse knapweed. Several pathogens can be quite destructive to diffuse knapweed, and include two fungi *Puccinia jaceae* var. *diffusaei,* which attacks the leaves, and *Sclerotinia sclerotiorum,* which attacks the crowns of both diffuse and spotted knapweed.

The seed head weevil (*Larinus minutus*) has caused remarkable reductions in diffuse knapweed density is some areas of Oregon and Washington with emerging success also reported in Colorado (Coombs et al. 2004). The seedhead flies *Urophora affinis* and *U. quadrifasciata* have been released in many Colorado Front Range counties. These insects cause plants to produce fewer viable seeds and abort terminal or lateral flowers (CSU 2006). Root-feeding insects may have a more detrimental effect on knapweed populations than seed-feeding ones. Larvae of the diffuse knapweed root beetle (Sphenoptera jugoslavica) feed in the roots of diffuse knapweed. Larvae of the yellow-winged knapweed moth (*Agapeta zoegana*) and the knapweed root weevil (*Cyphocleonus achates*) feed on the roots of both diffuse and spotted knapweed species (Coombs et al. 2004).

Cutting, mowing, or grazing aboveground portions of the plant before seed set may be an effective way to reduce seed production, but it will not eliminate the infestation. When a diffuse knapweed plant has been cut, the rosette may live and re-bolt. Additionally diffuse knapweed seeds can remain dormant for several years, requiring any cutting program to be repeated several times annually (spring, summer, and fall) to be effective. Goats will not eat dry seed heads. Reduction of surface biomass followed by a fall herbicide treatment would be more effective than grazing or mowing alone.

Several herbicides are relatively effective at controlling both diffuse and spotted knapweed. Picloram at 1 to 1.5 pt per acre or clopyralid at 0.33 to 1.33 pt per acre are the most widely recommended. Other less effective herbicides include imazapic, 2,4-D, and dicamba; metsulfuron is not effective against knapweeds (Dewey et al. 2006, CSU 2000). Apply herbicides during active growth with the optimum time from rosette to early bolting stage, or fall regrowth. Seeding with desirable grass species that will compete for resources but not be affected by broad leaf herbicides is critical to avoid the treated areas from returning to noxious weed communities.

#### 3.3.1.5 YELLOW STAR-THISTLE (*CENTAUREA SOLSTITIALIS*)


**Background**: This species was introduced from the Mediterranean region, and is well established in the Pacific coast states. It appears to favor dryland conditions, and will invade rangelands, pastures, roadsides, croplands, and wastelands. It is intolerant of shade and requires light on the soil surface for winter rosette and taproot development. Yellow starthistle is capable of establishing on deep, well-drained soils as well as on shallow, rocky soils that receive from 10-40 inches (25 to 100 cm) of annual precipitation (Whitson et al. 1999).

**Description**: Yellow starthistle is a winter annual forb with yellow flower heads located singly at the ends of branches. Flower heads are distinguished by sharp, straw-colored thorns, which are up to 0.75 inches (2 cm) long. Basal leaves are deeply lobed while the upper leaves are entire and sharply pointed. Mature plants are 2 to 3 feet (0.75 to 1 m) tall and have rigid, branching, winged stems that are covered with cottony hairs. Seedlings usually emerge in the fall, form rosettes, and begin

growing a taproot. Root growth continues throughout the winter. Yellow starthistle bolts in late spring, and flowers June through August. It reproduces entirely by seeds that may remain viable for several years. Plumed seeds are dispersed by wind shortly after maturity. Plumeless seeds remain in the seedhead until it disintegrates in the fall or winter.

**Control**: There are several biological control agents that can dramatically reduce seed production. The most commonly used biological control agent is *Bangasternus orientalis*, a seed head weevil. Larvae feed on the seeds and can destroy up to 60% of the seeds in a head. Reseeding with competitive grass species is a key part of integrated yellow starthistle control.

Cattle and sheep will graze yellow starthistle before it has spines, and multiple grazing periods are necessary to control it. However, yellow starthistle causes a neurological disorder called chewing disease (equine nigropallidal incephalomalacia) in horses that eat it.

Herbicides are effective when applied from the seedling to bolt stages in the spring, but most effective if rosettes are sprayed in the fall. Picloram, dicamba, clopyralid, and 2,4-D are the most commonly used herbicides. Seeding with desirable grass species that will compete for resources but not be affected by broad leaf herbicides is critical to avoid the treated areas from returning to noxious weed communities.

#### 3.3.1.6 SPOTTED KNAPWEED (*CENTAUREA STOEBE* SSP. *MICRANTHOS*)

**Background**: Spotted knapweed is indigenous to south-central and south-eastern Europe and northwestern Asia, and arrived in the United States as a contaminant in alfalfa seed. This knapweed species infests rangelands, pastures, roadsides, or any disturbed soils, and is estimated to have infested 3 million ha in the western United States ranking as the number one weed problem in western Montana. Their early spring growth makes them competitive for soil moisture and nutrients. Like most knapweeds, spotted knapweed releases chemical substances into the soil that inhibit the growth of competing vegetation. Spotted knapweed can cause skin irritation in some people, and anyone working with spotted knapweed should wear protective gloves and avoid getting knapweed sap into cuts or abrasions (CSU 2000).

**Description**: Spotted knapweed is a biennial or short-lived perennial forb with solitary pinkish-purple flowering heads at the ends of branches. The deeply lobed rosette leaves are up to 6 inches (18 cm) long, and the principal stem leaves are alternate, pinnately divided with smooth margins. Mature plants are 1 to 3 feet (0.25 to 1.0 m) tall, with one or more stems, and closely resembles diffuse knapweed. The flowering bracts of spotted knapweed have dark spots tipped with fringe, unlike the other knapweeds. This highly competitive weed invades disturbed as well as undisturbed areas degrading desirable plant communities. It forms near monocultures, and is adapted to well-drained, light to coarse-textured soils that receive summer rainfall. It tends to inhabit somewhat moister sites than diffuse knapweed, and is not tolerant of shade (Belliston et al. 2004).

Spotted knapweed germinates in spring or fall, and develops into rosettes for at least one growing season while root growth occurs. It usually bolts for the first time in May of the second growing season and flowers August through September. Individual flowers remain in bloom for 2 to 6 days, and can either self or cross-pollinate. Spotted knapweed reproduces entirely by seed, and seeds may remain viable in the soil for over 8 years (Belliston et al. 2004).

**Control**: Currently there is no single biological control agent that effectively controls knapweed populations. Several insects are either under investigation or have been released, but researchers believe that it will take a combination of methods to reduce knapweed infestations. The fungus *Sclerotinia sclerotiorum* attacks the crowns of both diffuse and spotted knapweed. However, this fungus is being studied and is not cleared for use for biocontrol of these knapweeds or for transportation across state lines. The root insects sulfur knapweed moth (*Agapeta zoegana*) and knapweed root weevil (*Cyphocleonus achates*) are having a significant impact on spotted knapweed. The sulfur knapweed moth larva attacks the cortex of the root. Eggs are laid on the surface of stems and leaves of knapweed and other vegetation. Eggs hatch in seven to 10 days, and the larvae migrate to the crown area where they mine the root. The knapweed root weevil larvae mine and gall the central vascular tissue of the root, and the adults feed on the leaves. Spotted knapweed is the preferred host for knapweed root weevil, but can also be used to attack diffuse knapweed (Coombs et al. 2004).

Goats grazing spotted knapweed at the bud to bloom stage have the greatest potential as a control tool. Grazing at the rosette to bolt stage does reduce seed count, plant count and canopy cover, but not at the levels of bud to bloom. Grazing twice reduces seed heads the most but results in increased plant count, perhaps because grazing disturbs the seed bank causing quicker germination or because the goats don't eat the dry seed heads, instead knocking them to the ground (Lamming 2001).

Several herbicides are relatively effective at controlling both diffuse and spotted knapweed. Picloram at 1 to 1.5 pt per acre or clopyralid at 0.33 to 1.33 pt per acre are the most widely recommended. Other less effective herbicides include imazapic, 2,4-D, and dicamba; metsulfuron is not effective against knapweeds (Dewey et al. 2006, CSU 2000). Apply herbicides during active growth with the optimum time from rosette to early bolting stage, or fall regrowth.

#### 3.3.1.7 SQUARROSE KNAPWEED (*CENTAUREA VIRGATA*)

**Background**: Squarrose knapweed is a highly competitive weed that can displace native rangeland plants. It grows aggressively in dry disturbed areas, particularly in sand or cinders such as roadsides or cinder pits. Like other knapweed species, squarrose knapweed releases allelopathic chemicals that inhibit the growth of other plants. Squarrose knapweed grows mainly in big sagebrush-bunchgrass rangeland, but is also found in salt desert communities. It prefers open habitats to shaded areas, and is not common on cultivated land or irrigated pasture because it cannot tolerate excessive moisture (CSU 2000).

**Description**: Squarrose knapweed is a perennial forb with small, numerous, pink colored flowers, usually developing no more than 3 to 4 seeds per head. This species is often confused

with diffuse knapweed, but differs principally in the fact that it is a true perennial, seed heads are highly deciduous falling off the stems soon after seeds mature, and the bracts are recurved with the terminal spine longer than lateral spines on each bract. The lower leaves are deeply dissected, and the upper leaves are bract-like. Mature plants are typically between 1 to 2 feet (0.6 to 0.6 m) tall with highly branched stems. The root system is a deep taproot (Belliston et al. 2004).

**Control**: Some biocontrol insects that attack spotted knapweed also attack squarrose knapweed, including the gall-forming flies *Urophora affinis* and *U. quadrifasciata*, although they have not been quantified for effectiveness.

Cutting, mowing, or removing the above ground portion of the plant, before seed set may be an effective way to reduce seed production, but it will not eliminate the infestation; the rosette may live and re-bolt after cutting. Since resprouting from the crown can occur, the entire plant must be removed. Timing of mowing is critical. Rosettes are robust to mowing and generally too low to be successfully cut. A single mowing in the bud to early flower stage may be effective, but mowing more mature plants will facilitate seed dispersal and is not recommended. Goats will graze the flowerheads and buds preferentially, followed by the green photosynthetic tissue (Lamming 2000). Squarrose knapweed seeds can remain dormant for several years, requiring any cutting program to be repeated annually to be effective.

Several herbicides are relatively effective at controlling knapweeds. Effective herbicides include picloram at 0.25 lb per acre, dicamba at 1 lb per acre, and clopyralid at 0.25 lb per acre. All three are most effective when applied in the spring, when plants are beginning to bolt. Picloram is the most effective treatment, followed by clopyralid and dicamba. Both clopyralid and dicamba will provide some residual control, particularly clopyralid, and retreatments may be necessary in the second, third, or fourth years. Dicamba will injure or kill most other broadleaves it contacts, including desirable species. Clopyralid is more selective, but will injure legumes such as clovers. 2,4-D is the least expensive treatment, but is less effective, and retreatment will be required every year (CSU 2000). Seeding with desirable grass species that will compete for resources but not be affected by broad leaf herbicides is critical to avoid the treated areas from returning to noxious weed communities.

### 3.3.1.8 CANADA THISTLE (*CIRSIUM ARVENSE*)

**Background**: This species can be confused with several other exotics. Bull thistle (*Cirsium vulgare*) has flower bracts that are somewhat tapered and covered with spines, scotch thistle (*Onopordum acanthium*) has stems that appear to have wings and floral bracts that are covered with spines, musk thistle (*Carduus nutans*) has floral bracts that are broad with spiny tips, and Russian knapweed with pointed papery tips on floral bracts. Canada thistle is an aggressive, creeping, perennial weed that infests crops, pastures, rangelands roadsides, and riparian areas. Although Canada thistle mainly invades disturbed area, it does invade native plant communities, open meadows, and wetlands. Canada thistle can tolerate saline soils, but does not tolerate waterlogged or poorly aerated soils.

**Description**: This 1 to 4 feet (0.3 to 1.3 m) perennial forb has white to purple flower heads borne in clusters of 1 to 5 per branch. Unlike other *Cirsium* species, Canada thistle is dioecious, and female flowers can be readily distinguished from male flowers by the absence of pollen and the presence of a distinct vanilla-like fragrance. It is possible for a community of male plants to maintain itself by asexual reproduction while producing no fruits. Flowering occurs from June to August, and seeds mature in October. The one-seeded fruits are straw or light brown in color, and can be straight or slightly curved. The leaves are spiny, alternate, oblong or lance-shaped, with the base leaves stalkless and clasping, and rosettes have wavy leaves with spiny tips. There are two types of roots; horizontal roots produce numerous shoots, while vertical roots store water and nutrients in their many small branches. The over-wintering root develops new underground roots and shoots in January that elongate in February. Shoots emerge between March and May forming rosettes. The plants remain near the soil surface until long days (over 14 hours of light) trigger stem elongation. It spreads rapidly through horizontal roots, which give rise to shoots, and can grow as much as 18 feet in one season. Although Canada thistle reproduces primarily vegetatively through creeping horizontal roots, seeds are viable in the soil for several years (CSU 2000).

**Control**: Currently, there are no biological control agents that effectively control Canada thistle. However, Canada thistle is attacked by several accidentally introduced insects, including the green tortoise beetle (*Cassida rubiginosa*), the native painted lady butterfly (*Vanessa cardui*), and the crown root weevil (*Baris subsimilis*). A rust fungus (*Puccinia carduorum*) can be found in some stands and will kill some plants. The seed head fly (*Terellia ruficauda*) may become abundant in some areas but causes little damage. The seed head weevil (*Larinus planus*) was accidentally introduced into the United States at an unknown time. This weevil is not recorded as a pest of any economically important plant, and is found to feed mainly foliage of *Cirsium* and *Carduus* species. It shows a preference for Canada thistle, although others, including the genera *Arctium*, *Onopordum,* and *Silybum* were acceptable if Canada thistle was not available (Coombs et al. 2004).

Goats will eat Canada thistle reducing biomass and stressing the plant. The most effective time to graze is when the plant is in full bud before it flowers. At this time, the plant has put all of its energy into seed reproductive structures, reducing root reserves. This can be an effective control if it is repeated in one-month intervals throughout the growing season. Over time, the Canada thistle will spend more energy reproducing photosynthetic tissue, and after two or three grazings will eliminate all root reserves and die (Lamming 2001).

Fall herbicide treatments are more effective as absorption is enhanced in the late summer and fall when shoot to root translocation is the greatest. However, translocation of the herbicide is dependent on moist soil conditions, and must be timed accordingly. Aminopyralid (5-7 oz per acre), picloram (1-2 qt/acre), clopyralid (0.66 to 1.3 pt/acre), and clopyralid + 2,4-D (Curtail®) (4-6 pt per acre) are effective when applied in the late spring or fall. Be sure to apply to actively growing parts of the plant. The performance of herbicides can be improved when proceeded by two or three mowings, cuttings, or grazings under conditions when the root systems are stressed. Spring application should be timed to the rosette to bud growth stages. Chlorsulfuron and glyphosate offer good control, and dicamba is not recommended against Canada thistle (Dewey et al. 2006, CSU 2000). Seeding with desirable grass species that will compete for resources but not be affected by broad leaf herbicides is critical to avoid the treated areas from returning to noxious weed communities.

### 3.3.1.9 FIELD BINDWEED (*CONVOLVULUS ARVENSIS*)


**Background**: Field bindweed is also called small-flowered morning glory, wild morning glory, creeping Jenny, and European bindweed. This European native apparently contaminated crop seed and was identified in Virginia as early as 1739. It is similar in appearance to other species in the Convolvulaceae family (Belliston et al. 2004).

**Description**: Field bindweed is a persistent, perennial vine that spreads by rhizome and seed. Flowers last for only one day, and are produced late in June until conditions are no longer favorable. The extensive underground root/stem system allows some to persist through the winter, and the lateral roots can persist independently if severed from the primary root. Young plants extend a taproot deep into the soil, and then form lateral roots. Initially, these lateral roots function as feeding roots for aboveground growth, but later aid in vegetative reproduction. Buds may arise anywhere on the lateral roots. Eventually, the lateral roots begin growing downward, and new shoots on the root may produce aboveground growth or additional lateral roots. Lateral root growth was found to be 15 feet (4.6 m) per year, but depends on the soil permeability and water table depth (TNC 2006).

Seedlings emerge from the soil erect and ascending, and are often found in irrigated agricultural fields or moist locations such as riparian corridors and irrigated areas. The deep roots store carbohydrates and proteins, and help field bindweed spread vegetatively by resprouting repeatedly following removal of aboveground growth. Seeds are extremely persistent, and can lie

dormant in the soil for many years. The seed coat must be exposed to adequate water, moist air, or fluctuating soil temperatures in the surface soil layers in order for a seed to germinate. New introductions of field bindweed are most likely by seed. Seeds fall near the parent plant, but can be transported by water or birds. Seeds pass through the stomachs of migrating birds with little or no damage (CSU 2000).

**Control**: Control has been most successful when aboveground biomass is consistently removed, causing underground stores of energy to be tapped. The bindweed gall mite (*Aceria malherbae*) forms galls on the leaves, petioles, and stem tips. The folding or twisting upward along the midrib where the mites feed is visual identification that the bindweed gall mite has attacked the plant. When the stem buds are attacked, they fail to elongate and thus form compact clusters of stunted leaves. These mites stunt the plant and reduce flowering. The mite may be difficult to establish in a field under cultivation or herbicide treatment, thus a site less aggressively managed may be a better location for release. Population of the mite are generally slow to develop, and may take up to three years. Once established, the mite may disperse via the wind and spread rapidly. The mite could also potentially infest native species, therefore release is not recommended for locations in which nontarget impacts may be a concern (Coombs et al. 2004).

Herbicide application is most effective when the herbicide will be translocated to the roots before the seed can be set. Control of field bindweed entails chemical applications and removal on a yearly basis. The herbicide picloram at 0.5 to 1.0 pt per acre is generally the most effective, and can be applied at any time of the year when field bindweed runners are 8 to 12 inches (20 to 30 cm) long. Glyphosate, dicamba, and 2,4-D can provide some control. Early spring requires the plant to draw from its roots, and the majority of translocation will be from below to above ground. Once above ground growth is vigorous, translocation is primarily from the shoot to the roots and herbicide application should be done at this stage in the fall to ensure it is moved with the photosynthates to the roots and root buds. If the aboveground portion is continually destroyed, the root eventually starves and dies. However, if the aboveground portion is allowed to regenerate and feed the root system, the plant will continue to flourish. The key to implementing a successful control program is to continue treatment even after it appears the infestations are significantly reduced. Three to five years may be required to effectively reduce the seed source, deplete food reserves in the root system, and prevent seedling regrowth.

Burning in itself is not an effective control method, but may be useful in combination with other methods. Similarly, tilling breaks up the roots, and may actually increase the number of seedling or sprouts from the severed roots without herbicide application. Grazing can reduce aboveground biomass, but field bindweed can be poisonous to cattle. Hogs, sheep, and goats will graze field bindweed, but it must be in conjunction with herbicide application or the area fully recovers following grazing cessation (Lamming 2001).

### 3.3.1.10 BERMUDAGRASS (*CYNODON DACTYLON*)

**Background**: Bermudagrass is a major turf species for sports fields, lawns, parks, golf courses, and general utility turfs in Australia, Africa, India, South America and the Southern region of the United States. It is found in over 100 counties throughout the tropical and subtropical areas of the world. It naturalized throughout the warmer regions of the United States, after it was introduced during the colonial period from Africa or India. The earliest introductions are not recorded, but bermudagrass is listed as one of the principal grasses in the Southern States as early as 1807 (Duble 2006).

**Description**: Bermuda grass is a mat-forming rhizomatous grass that moves along the ground and forms adventitious roots wherever a node touches the ground. It has a deep root system that can grow 47 to 59 inches (120-150 cm) deep in drought situations. Its blades are a gray-green color and are usually 1 to 4 inches (3-10 cm) long with rough edges. The erect stems can grow 0.3 to 1.3 feet (0.1-0.4 m) tall. The stems are slightly flattened, and the inflorescence is purple in color (Belliston et al. 2004).

Bermuda grass reproduces through seeds as well as rhizomes. The seedheads are on 1-3 inch (3-7 cm) spikes and are about 2 inches (5 cm) long. Bermuda grass will put out seeds about 3 months after germinating. The seeds germinate at temperatures above 68° F (20° C), and begin to grow within 2 weeks. One plant can cover an area of 3 square yards (2.5 sq m) in just 150 days after germinating. Bermuda grass can grow in poor soil, but it prefers moist and warm climates with over 16 inches (40.5 cm) of rainfall per year.

**Control**: Bermudagrass is a drought tolerant grass often used as turf and ornamental groundcover. It is considered very invasive and competitive weed, and few herbicides are effective against it. Goats prefer broadleaved plants over grasses, but will graze young shoots if nothing else is available (Lamming 2001).

### 3.3.1.11 QUACKGRASS (*ELYMUS REPENS*)

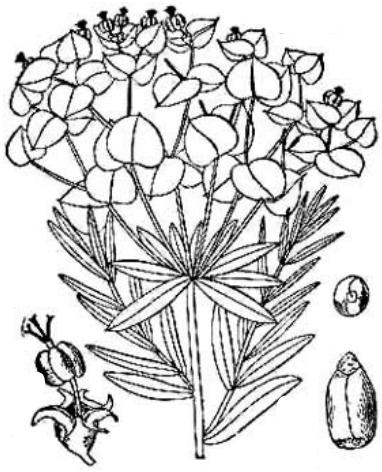
**Background**: Originally found in the Mediterranean area, quackgrass infests crops, rangelands, pastures, and lawns. It adapts well to moist soils in cool temperature climates (Belliston et al. 2004).

**Description**: This 1 to 3-foot (0.25 to 1 m) tall perennial grass has spikelets arranged in two long rows that are borne flatwise to the stem. Quackgrass leaves are often constricted near the tips, are flat, pointed, between 0.25 and 0.5 inche (0.5 to 1.75 cm) wide, and have small ear-like appendages at the junction of the blade and the sheath. Both leaf sheath and blade are hairless or sparsely hairy. Plant vigor is reduced when shading exceeds 50 % (Belliston et al. 2004).

Quackgrass propagates mainly by rhizomes but also reproduces by seed, and primary rhizome growth begins in early spring and then again in September and October with the onset of fall rains and cooler temperatures. Quackgrass flowers from June through August. Cross-pollination is necessary for seed production. Seeds germinate in fall or spring and plants are capable of producing seeds more than once per season, and can remain viable for up to 10 years.

**Control**: No biological control methods are available at this time. Because of the ability of broken rhizome segments to grow and produce more plants, it is extremely difficult to control mechanically by tilling or ripping the soil subsurface. Mowing and raking can reduce quackgrass biomass, and prevent flowering the following season. It can be effectively controlled with glyphosate, nicosulfuron, fluazifop-P-butyl, imazapyr, and princep (USDA 2006).

### 3.3.1.12 LEAFY SPURGE (*EUPHORBIA ESULA*)



**Background**: This is an aggressive, long-lived, perennial weed that tends to displace all other vegetation in rangeland, pasture, and native habitats. Leafy spurge decreases rangeland diversity, threatens native plants and degrades wildlife habitat. It is most aggressive in semi-arid areas, but can be found in xeric to subhumid and subtropic to subarctic habitats. Leafy spurge occurs most commonly on untilled, non-crop areas such as rangelands, pasturelands, woodlands, prairies, roadsides, stream and ditches, and waste sites. It grows on all kinds of soils, but is most abundant in coarse-textured soils and least abundant on clay soils (CSU 2000).

People should handle the plant with caution because the latex can cause irritation, blotching, blisters, and swelling in sensitive individuals. Eye irritation can be severe. The dried latex is often very difficult to wash off, and latex gloves should be used when handling this plant (Coombs et al. 2004).

**Description**: Leafy spurge is a perennial forb with yellowish-green flowers arranged in numerous small clusters subtended by paired heart-shaped yellow-green bracts. The leaves are alternate, and 1-4 inches (2-10 cm) long. Mature plants are up to 3 feet (1 m) tall, and the entire plant contains white, milky latex. Leafy spurge is one of the earliest plants to emerge in the spring, usually in mid-April to late May. The development of terminal flower clusters begins 1 to 2 weeks after stem emergence. Flower clusters have 8 to 16 branches. Flowering generally ends in late June to mid-July, and growth is reduced during the hotter portion of the summer. However, if conditions are favorable, leafy spurge may produce a few lateral flowers throughout the summer and in the fall (CSU 2000, Belliston et al. 2004).

Leafy spurge produces a large number of seeds and underground shoot buds. These two reproductive techniques allow it to rapidly displace native species forming a monoculture. Rapid re-establishment of treated stands often occurs after an apparently successful management effort because of the large nutrient reserve stored in the roots of leafy spurge plants. Primary reproduction is vegetative through its extensive lateral root system. Long roots have the

capability to produce shoots and can reach nearly 15 feet (5 m) laterally, and about 30 feet (10 m) in depth. Seeds can remain viable in the soil for 5 to 8 years, although 99% of the viable seeds will germinate in the first two years (CSU 2000, Belliston et al. 2004).

**Control**: Biological control is still being investigated, and successful control may require a combination of insects and long-term management. The USDA Agriculture Research Service (ARS) has released fifteen species in an effort to control leafy spurge. The most effective biological control agents seem to be six species of root- and foliate-feeding beetles in the genus *Aphthona*, and a stem- and root-boring beetle *Obera erythrocephala*.

Grazing sheep or goats has been successful, but spurge quickly returns if grazing is removed. Grazing is likely to be most effective in the spring and summer when the spurge plants are succulent. Whereas sheep generally can be taught to feed on it, goats will seek it out. Another benefit is that goats grazing on leafy spurge do not need water during the day, although they may need water at night (Lamming 2001).

Herbicides can provide some control of leafy spurge, however, due to its extensive root system and general hardiness, follow up applications are necessary. It apparently has the ability to purge undesirable chemicals from the root system in approximately the top (18 inches) 45 cm of the soil, allowing the remaining portion of the root system to regenerate as soon as the effect of the chemical in the soil has dissipated (Coombs et al. 2004). Picloram is recommended for eradication of small infestations, with herbicide application extending for 10-15 feet (3-4 m) beyond the leafy spurge patches. A combination of Picloram and 2,4-D proved good results when applied in the spring when flowers emerge (CSU 2000).

#### 3.3.1.13 DYER'S WOAD (*ISATIS TINCTORIA*)

**Background**: Dyer's Woad origins date back over 2000 years. In Europe, this plant was cultivated as a source of blue dye and medicinal properties. This aggressive weed infests disturbed and undisturbed sites, and can spread outward into crops and rangelands. It appears to be well adapted to the physical and environmental conditions of the Intermountain states, and is especially well suited to dry, rocky soils common to many steep hillsides. Dyer's woad is commonly found on disturbed sites, along roadsides, waste areas, and right-of-ways (Belliston et al. 2004).

**Description**: Dyer's woad is a winter annual, biennial, or short-lived perennial forb ranging from 1 to 4 feet (0.3 to 1.3 m) tall. The flowers are bright yellow, and seedpods are black or purplish-brown with a single seed. The basal rosette leaves are 3 to 4 inches (7.5 to 10 cm) long, and are lance-shaped and connected to the stem with a petiole. The upper stem leaves are simple, alternate, bluish green with a whitish nerve on the upper surface. These leaves clasp the stem with an ear-like projection, and decrease in size toward the top of the stem. Mature plants have a thick taproot that my exceed five feet (1.5 m) in length (CSU 2000).

Established dyer's woad plants begin growth early in the year. The plant has a deep taproot as well as roots near the soil surface. Early growth plus the two-tiered root system probably account for its competitive ability. It germinates in the fall or early spring, and develops rosettes that

produce large taproots during the first year. The following spring, new leaves grow from the crown bud in the rosette, and bolting begins. Flowering occurs in late spring, although timing is dependent upon elevation. Dyer's woad reproduces mainly by seed, but seeds do not remain viable in the soil for long periods of time (Belliston et al. 2004).

**Control**: Removal is probably the simplest and most effective method of control, if removed after plants have bolted and begun to flower. There are several CWMAs that utilize local volunteers to pull Dyer's Woad in Utah in the "Bag-O-Woad" program. For small distinct populations, this is a valuable opportunity to eliminate the infestation, engage in the community, and support education regarding this and other noxious weeds.

It is commonly controlled with herbicides. Metsulfuron offers excellent control at 0.33 to 2 oz per acre; apply post emergence when the ground is not frozen in March or April. 2,4-D, imazapic, and chlorsulfuron offer good control at 1.75 qt/acre, 10 oz/acre, and 1 oz/acre respectively. Use any of these herbicides to avoid injury to grass species.(CSU 2000).

A relative of the rust fungus *Puccinia thlaspeos* is the most common biological control agent used, and is able to prevent or reduce seed production and slow growth. The rust can enter the plant through inoculation on the leaf surface and systemically damages the plant to the roots. It can prevent or reduce seed production and may also affect the survival of seedlings, rosettes, and overwintering plants. The rust is able to complete its life cycle on dyer's woad alone and does not seem to require a secondary host like many rusts do. Rust infected plants will have yellowish puckered leaves with dark spots on the underside (Weber County 2006).

### 3.3.1.14 PERENNIAL PEPPERWEED (*LEPIDIUM LATIFOLIUM*)

**Background**: Perennial pepperweed, or tall whitetop, is listed as a noxious weed in the state of Utah. It is a highly invasive herbaceous perennial, and can invade a wide range of habitats including riparian areas, wetlands, marshes, and floodplains. Once established this plant creates large monospecific stands that displace native plants and animals and can be very difficult to remove. Significant amounts of litter can build up in dense infestations. Old stems take several years to degrade and form a layer impenetrable to light. This deep litter layer prevents the emergence of annual plants and may reduce competition from other species. Even if perennial pepperweed is controlled, it may be necessary to remove the litter to stimulate germination and growth of desirable plant species (CSU 2000, TNC 2006).

**Description**: This plant reaches 4 feet (1.5 m) in height. Roots consist of annual, perennial, and semi-woody root crowns that creep horizontally below the soil surface, but never forming dense clusters. This low root density allows soil erosion to occur more frequently along infested riverbanks. The stems originate from large perennial belowground roots and emerge in early spring/late fall as rosettes that remain for several weeks before stems elongate or bolt. Rosette leaves are approximately 12 inches (30 cm) long and 3 inches (8 cm) wide with serrate margins

on long petioles. Stems have lanceolate gray-green leaves that are highly reduced and tapered at the base with entire to weakly serrate margins. Shoots flower with white dense clusters of flowers on racemes and fruit during late spring; flowering can continue throughout much of the summer. Plants senesce by mid to late summer while fruits remain on the stem. Seedlings are rarely found in the field; they lack a hard coat and do not seem to be capable of surviving long periods in the soil suggesting seed viability may be short. This suggests that reinfestations from the seedbank may not be a problem once control is achieved (CSU 2000, TNC 2006).

**Control**: No biological insects or pathogens are available for perennial pepperweed; few biocontrols are available for any member of the *Brassicaceae* family. This may be due to the high number of native species in this family, as well as the numerous crops, such as broccoli, cauliflower and cabbage (TNC 2006).

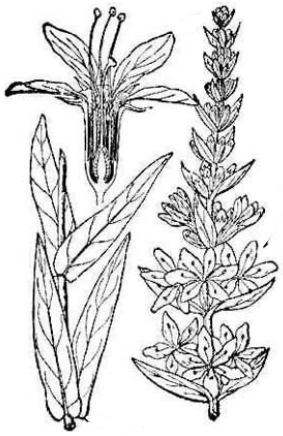
The only biological control currently available is grazing. Cattle, sheep, and goats will graze perennial pepperweed, although when stands are dense it becomes very difficult for these animals (except goats) to use it as forage. Cattle will graze the rosette leaves early in the spring, but have difficulty if previous year's stems are not removed. Some reports suggest the foliate may be poisonous (TNC 2006, Young et al. 1997).

Mechanical controls include flooding, disking, and mowing. Burning has not shown to be an effective control measure against perennial pepperweed, and in fact may increase the infestation. Burning does not harm the existing below ground root system, and the removal of litter and addition of nutrients from the fire favor resprouting stems. It can, however, be efficient in removing the litter layer and past stems. Flooding may reduce perennial pepperweed infestations after two consecutive years, and may be as influenced by the water inundation as competition from flood adapted desirable plants. Disking fragments perennial pepperweed roots which may increase infestation because the fragments can produce a shoot within three weeks. Mowed plants quickly recover within fourteen days, and produce larger leaves lower to the ground. Although, combining disking, mowing, and herbicide application provides the most effective control (TNC 2006).

The most consistent control is found when the infestation is disked in the fall, mowed in the spring between flowerbud and flower, and the resprouting foliage is sprayed with chlorsulfuron or metsulfuron (2-3 weeks later depending on soil moisture). Disking minimizes the amount of stored energy each plant has to grow by breaking roots into small fragments. Consequently, the newly sprouted plants will not have the supporting root structure in the spring. Mow the previously disked areas the following spring between flowerbud to flowering stage results in plants with different leaf structure. Unmowed plants have small leaves perpendicular to the ground the entire length of the stem, whereas mowed plants have numerous larger leaves parallel to the ground. Applying chlorsulfuron or metsulfuron to these leaves enhances the absorption and translocation of the herbicide to the root tissue. Soil moisture is an important factor limiting resprouting following mowing; new tissue is essential to provide ample surface for herbicide deposition. Chlorsulfuron and metsulfuron provide excellent control after one year, but are not approved for use over water. Aquatic formulations include glyphosate and imazapyr, and provide good control if used following disking and mowing, but may require follow up spot spraying for

several years. The herbicides 2,4-D and picloram are not effective against perennial pepperweed (CSU 2000, TNC 2006).

### 3.3.1.15 PURPLE LOOSESTRIFE (*LYTHRUM SALICARIA*)



**Background**: Purple loosestrife is a European plant probably introduced to the United States as an ornamental. It reproduces by both seed and creeping rootstocks. Infestations can impede water flow and replace beneficial plants and thus displace wildlife. It can be found in shallow marsh wetland areas and ditches.

**Description**: The purple loosestrife stems are erect, 1.5 to 8 or more feet tall (1 to 10 m), four to six angled, and can be smooth or pubescent with few branches. Leaves are simple, 0.75 to 4 inches (1 to 20 cm) long, 0.2 to 0.5 inches (0.5 to 1.5 cm) wide, entire, and can be opposite or whorled. The most identifiable characteristic of purple loosestrife is the striking rose to purple colored flowers. The flowers are arranged on a spike, which can be a few inches to 3 feet (1 m) long. Each flower has five to seven petals arising from a cylindrical green tube. The plant usually flowers from early July to mid-September. The seed capsule is two celled and contains many very small seeds (1 mm long or less). The roots become thick and woody in mature plants. The aerial shoots die in the fall and new shoots arise the following spring from buds at the top of the root crown. Although the root crown expands and produces more shoots each year, the maximum growth of the root crown diameter is limited to about 20 inches (50 cm). Spread of purple loosestrife is primarily by seed, but the plant can also spread vegetatively from stem cuttings (Belliston et al. 2004, USDA 2006).

**Control**: The purple loosestrife biocontrol project is one of the most widely implemented projects in the United States. The black-margined loosestrife beetle (*Galerucella calmariensis*) and golden loosestrife beetle (*Galerucella pusilla*) attacks buds and leaves. Adult and larval feeding upon the buds results in stunted plants and reduced seed production. After emerging from soil litter or from off site in the early spring, adults feed on exposed shoots that are about 2 to 4 inches (5 to 10 cm) long. With heavy defoliation, the host plant becomes skeletonized and turns brown. Heavily defoliated plants may die or produce fewer shoots the following year. However, these beetles can feed on two native plants (*Decodon verticillatus* and *Lythrum alatum*) and two introduced plants (*L. hyssopifolia* and *Lagerstroemia indica*), but do not reproduce on these hosts (Coombs et al. 2004).

The loosestrife root weevil (*Hylobius transversovittatus*) larvae live in the roots while the adults feed on the foliage. The larval effects are dependent upon root size, attack intensity, and duration. Small roots can be destroyed within two years if infested by several larvae. Larger roots may die after several consecutive years of infestation. This species increases and spreads more slowly than the leaf beetles. However, since during the growing season it feeds continuously on the root storage reserves of the plants, it is an important agent in the control of purple loosestrife. In stands of large, healthy plants, the leaf beetles may produce temporary severe defoliation, but the plants may recover after the beetles enter diapause in midsummer. By reducing root storage reserves, the weevil limits the plant's ability to recuperate after defoliation.

The combined impact of both biocontrol agents is enough to cause plants to die (Coombs et al. 2004).

The loosestrife seed weevil (*Nanophyes marmoratus*) adult and larvae attack unopened flower buds. Flower buds that are fed upon by either adults or larvae usually abort and fail to produce seeds. The loosestrife seed weevil tolerates a wide range of environmental conditions and possesses an excellent host-finding ability. It has successfully overwintered on exposed islands in an estuary with high tidal exchange where multiple releases of the leaf beetles have failed. The weevils can also persist where plants are scattered at low densities. Their impact is currently being overshadowed by the dramatic defoliation and plant death caused by the leaf beetles and root weevil. However, they may play an important role after loosestrife abundance declines and the other agents become less effective (Coombs et al. 2004).

Herbicide control includes the use of 2,4-D, metsulfuron, and glyphosate; dicamba offers fair control. Purple loosestrife is often found along stream banks and in riparian areas, and the aquatic formulation for these herbicides is available (Dewey et al. 2006).

### 3.3.1.16 SCOTCH THISTLE (*ONOPORDUM ACANTHIUM*)

**Background**: Scotch thistle is a native of Europe that quickly invades sunny areas that have been disturbed, but is suppressed when invading into a healthy system. Once established, it becomes highly competitive often crowding out other noxious weeds, and can form stands so dense they are impenetrable to livestock. Its rapid growth and large size reduce available light for smaller plants, and draws away other needed resources. Long spines intimidate animals into eating easier targets. When a scotch thistle dies, it leaves abundant litter that can smother surrounding plants. It is best adapted to high soil moisture and is often associated with waterways in the western U.S in disturbed areas where competition has been reduced. Although high soil moisture is preferred, it will occupy dry sites as well. Scotch thistle is often associated with plant communities dominated by annual weedy grasses (cheatgrass) and has been known to invade crested wheatgrass sites. It grows along roadsides, fence lines, ditch banks, open dry areas, and in pastures, but is rarely found in gardens and areas cultivated yearly (CSU 2000).

**Description**: This biennial plant commonly grows 3 to 8 feet (1 to 3 m) tall, but it may grow as high as 12 feet (4 m). Rosettes may be 4 feet (1 m) wide. Large spiny leaves up to 2 feet (0.75 m) long and 1 foot (0.25 m) wide are covered with dense hair, giving a grayish blue-green coloration. The flowers are violet to reddish with spine tipped bracts. The scotch thistle plant blooms in mid summer, and averages 70-310 flowers per plant, with 110-140 seeds per flowering head. Eighty to ninety percent of the seed can be dormant for approximately 5 years, and are dispersed by water, wind, animals, and human activities (Belliston et al. 2004).

**Control**: Control of these plants must include preventing new seed dispersal for up to 6 years. Grazing young plants with sheep or goats will remove aboveground biomass, and eliminate the spread of seed (CSU 2000). No other biological controls are available at this time.

Scotch thistle is most often controlled with herbicides, and can be combined with musk thistle treatments. The most effective chemical control occurs when musk thistle is still in the rosette stage, and quickly decreases once the plant has bolted. Picloram and metsulfuron offer excellent control when applied at 10-16 oz per acre and 0.5 to 1., oz per acre respectively. Apply both herbicides to rosettes; fall is optimal although spring applications are also effective. Clopyralid at 0.66 pt per acre, chlorsulfuron at 0.5 to 1.0 oz for musk thistle and 1 to 3 oz per acre for Scotch thistle, and a combination of clopyralid and 2,4-D (Curtail®) at 1 to 2 qt per acre provide good control when applied from the late rosette stage to early bolting. Seeding with desirable grass species that will compete for resources but not be affected by the broad leaf herbicides is critical.

#### 3.3.1.17 JOHNSONGRASS (*SORGHUM HALEPENSE*)

**Background**: Johnsongrass was introduced from the Mediterranean to the United States as a forage grass. However, when under frost or moisture stress, it forms hydrocyanic acid that is toxic to livestock. It aggressively crowds out native species, especially along riverbanks and ditches (Belliston et al. 2004).

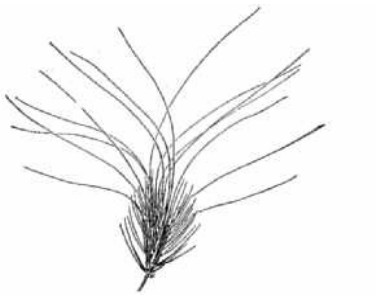
**Description**: Johnsongrass is a hardy warm season perennial grass with erect stems two to eight feet (0.5 to 3 m) tall that may be rusty red near the base. The mature flowers are large open panicles that bear many awn-tipped, shiny, reddish to purplish spikelets, with reddish-brown, awned seeds. Leaf blades are flat with conspicuous midveins, and are often as much as one inch (2.5 cm) wide. Both leaf sheath and blade are hairless, and ligules are prominent, jagged and membranous (CSU 2000).

Johnsongrass has thick, creeping rhizomes that are usually present at an early stage. Colonization can occur from both rhizomes and seed, and seeds can remain viable for over 2 years in the soil (Belliston et al. 2004).

**Control**: Small infestations can be controlled by hand pulling the plants when the soil is moist. Mowing after seed head development but before flowering can be used. However, acceptable results will usually require multiple mowings per year over several growing seasons by depleting the nutrient reserves in the root system. Care should be taken not to spread rootstock pieces as they can reestablish (CSU 2000). Due to the toxicity of Johnsongrass, grazing should be carefully monitored.

Chemicals are usually effective in control of Johnsongrass; Glyphosate at 1.5 lb ai/acre when the plants are 12 to 18 inches (30 to 50 cm) tall or Fluzifop-P-butyl at 43-48 oz/acre when seedlings are actively growing and between 2 to 8 inches (5 to 15 cm) tall. Sulfometuron methyl can be applied early post-emergence with a reapplication when regrowth begins, and works best when applied when soils are moist to help translocate the herbicide to the root system (CSU 2000).

### 3.3.1.18 MEDUSAHEAD (TAENIATHERUM CAPUT-MEDUSAE)



**Background**: Medusahead was brought to the United States from Eurasia in the late 1880s. Medusahead is a major concern to the range livestock industry because it can suppress desirable vegetation, and is unpalatable to livestock. When dry, dead vegetation decomposes slowly and forms a persistent dense litter on the soil surface. As the plant matures it develops long barbed awns that can cause injury to the eyes, nose, and mouth of grazing animals. Medusahead has little to no feed value to livestock at any stage of growth, although livestock will utilize it when other feed is limited (USFS 2006).

Medusahead and cheatgrass overlap in distribution and habitat requirements. Each can replace other herbaceous vegetation and share dominance with the other. Cheatgrass occupies a larger geographical area than medusahead, which extends to drier areas of the semi-arid western U.S. Medusahead maintains its dominance on sites where native vegetation has been eliminated or severely reduced by overgrazing, cultivation, or frequent fires. It has invaded seral communities in eastern Oregon and Idaho and replaced cheatgrass as the dominant alien grass (USDA 2006).

**Description**: This winter annual grass ranges from 6 inches (15 cm) to 2 feet (0.6 m). The leaf blades are narrow, about 1/8 inch (2 mm) wide in size. The 4-inch (10-cm) seed awns become twisted as the seed matures. It is sometimes confused with foxtail barley or squirreltail, but is different in that the seed head doesn't break apart completely as the seeds mature (Belliston et al. 2004).

Medusahead is entirely dependent upon seed production for regeneration. It is an extremely capable seeder because of its large annual production of viable seed, and because its seed maintains viability in litter and soil for at least 1 year. Plants produce up to 6,000 seeds/$ft^2$ of soil, propagating dense stands in succeeding years. Medusahead is principally self fertile, and most of the pollen grains are dispersed within the floret and only a moderate number of pollen grains are produced in each of the short anthers.

**Control**: Two smut diseases that eliminate seed production were identified by USDA-ARS in 2002-2003, and are currently being researched (USDA 2006). Burning medusahead can destroy large amounts of seeds if the seedhead has not disseminated, reducing the stand by 60 to 95% in the next growing season. A slow burn in dense medusahead stands that occur on well-developed soil profiles may reduce seed production. On less developed soil profiles where prescribed fire is not feasible, grazing livestock when plants are actively growing, herbicide treatment, reseeding, or a combination of these methods may be tried. Imazapic has been shown to be effective on medusahead.

Chemicals are usually effective control; Glyphosate at 1.5 lb ai/acre when the plants are 12 to 18 inches (30 to 50 cm) tall or Fluzifop-P-butyl at 43-48 oz/acre when seedlings are actively growing and between 2 to 8 inches (5 to 15 cm) tall. Sulfometuron methyl can be applied early

post-emergence with a reapplication when regrowth begins, and works best when applied when soils are moist to help translocate the herbicide to the root system (CSU 2000).

## 3.3.2 County-listed Noxious Weed Species

### 3.3.2.1 JOINTED GOATGRASS (*AEGILOPS CYLINDRICA*)

**Background**: Jointed goatgrass is native to Europe, and has become a serious invader of winter wheat crops spread by farm machinery in the United States. It also thrives along roadsides, in pastures, on rangelands, and in waste areas (Belliston et al. 2004). Jointed goatgrass is listed as a noxious weed by Tooele County, and is found throughout Salt Lake County from the valley floor to midmontane habitats in dry, disturbed sites (Belliston et al. 2004, USDA NRCA 2006)

**Description**: This winter annual grows 15 to 30 inches (0.5 to 1.0 m) tall, and may have one or more upright stems or tillers. Leaf blades are 1/8 to 1/4 inch (2 to 5 mm) wide, alternate, hairy, simple, and have auricles at the base. The spike is cylindrical, and contains 2 to 12, 1/2 inch (1 cm) spikelets that fit into the contour of the rachis. Glumes are ribbed with a keel on one side extending into a single awn. As the seeds mature, the plant turns from green to a reddish or tan color. Flower and seed production take place from late spring to mid summer (Whitson 1999).

**Control**: Biocontrol is not available. Chemicals are usually effective; Glyphosate at 1.5 lb ai/acre when the plants are 12 to 18 inches (30 to 50 cm) tall or Fluzifop-P-butyl at 43-48 oz/acre when seedlings are actively growing and between 2 to 8 inches (5 to 15 cm) tall. Sulfometuron methyl can be applied early post-emergence with a reapplication when regrowth begins, and works best when applied when soils are moist to help translocate the herbicide to the root system (CSU 2000).

### 3.3.2.2 BULL THISTLE (*CIRSIUM VULGARE*)

**Background**: Bull thistles is native to Europe, and now infests much of North America. It is often found in pastures, fields, roadsides, and disturbed sites. It is most common in lower, heavier soils, and moist areas (Belliston et al. 2004). This species is only listed as a noxious weed in Beaver County, however its distribution covers the entire state of Utah (USDA NRCS 2006).

**Description**: Bull thistle is a biennial with a short, fleshy taproot, forming a rosette the first year and bolting and flowering the second year. The stem is 2 to 5 feet (0.5 to 2 m) tall, bearing many spreading branches, green or brownish, sparsely hairy, with irregularly and spiny wings. Leaves are highly lobed, prickly on upper surface and cottony underneath. This is a distinguishing character for bull thistle; Canada thistle leaves are glabrous above and glabrous or hairy below. Flowers are 1 to 2 inches (2.5 to 5 cm) wide and are pinkish-purple, and clustered at the end of the branches. Involucrel bracts are narrow, spine-tipped, progressively longer and narrower from outer to inner ones. Flowering occurs between July through September. Seeds are tipped by a circle of plume like white hairs (Whitson 1999).

**Control**: Biocontrol is available.

Repeated mowing, hand pulling, or grazing can be used to stop the spread of musk thistle. Mowing or grazing after flowering but before seed set prevents seed development and dispersal. When pulling musk thistle it is important to completely remove the crown so that the plant does not simply re-bolt and produce seeds. Repeated visits at weekly intervals over the 4 to 7 week flowering period is necessary when removing aboveground biomass because not all plants flower at the same time.

Bull thistle is most often controlled with herbicides. The most effective chemical control occurs when musk thistle is still in the rosette stage, and quickly decreases once the plant has bolted. Picloram and metsulfuron offer excellent control when applied at 10-16 oz per acre and 0.5 to 1., oz per acre respectively. Apply both herbicides to rosettes; fall is optimal although spring applications are also effective. Clopyralid at 0.66 pt per acre, chlorsulfuron at 0.5 to 1.0 oz, and a combination of clopyralid and 2,4-D (Curtail®) at 1 to 2 qt per acre provide good control when applied from the late rosette stage to early bolting. Seeding with desirable grass species that will compete for resources but not be affected by the broad leaf herbicides is critical.

### 3.3.2.3 POISON HEMLOCK (*CONIUM MACULATUM*)

**Background**: Poison hemlock is native to Europe, and is generally found on dry to moist soils, can tolerate poorly drained soils, and tends to be scattered in riparian areas. It is usually found along streams, roadsides, and irrigation ditches. It has been mistaken for parsley and wild carrot. All parts of the plant are toxic (CSU 2000). This species is listed by Davis, Cache, and Rich Counties as a noxious weed species, but is found in Salt Lake County throughout riparian areas (USDA NRCS 2006)

**Description**: Poison hemlock grows 6 to 10 feet (2 to 3 m) tall. This biennial forb has white flowers that are borne in umbrella-like clusters that are supported by a stalk. Seeds are generally light brown, ribbed, and concave. The shiny green and finely divided leaves are alternate, but may be opposite above. Leaflets are segmented on short stalks, and seedling leaves have a fernlike appearance (Belliston et al. 2004).

**Control**: The European palearctic moth (*Agonopteris alstoemeriana*) feeds exclusively on poison hemlock, and offers fair to good control. Poison hemlock can be controlled by digging, repeated mowing, pulling, or by spring and winter burns. Herbicides can offer excellent control when applied to actively growing plants between rosette and bolt stages. Tebithuron provides pre-emergent control, and chlorsulfuron and chlorsulfuron with metsulfuron provide both pre-emergent and foliar control. Picloram, dicamba, 2,4-D at 1 lb ai/acre, or glyphosate at 1.5 ai/acre can also be used (CSU 2000).

### 3.3.2.4 HOUNDSTONGUE (*CYNOGLOSSUM OFFICINALE*)

**Background**: Houndstongue was introduced from Europe in the late 1800s, and was accidentally included as a contaminant in seed. It can be found in disturbed habitats, primarily in pastures, rangelands, and along roadsides (USDA NISIC 2006). Houndstongue is listed as a noxious weed

in Tooele, Wasatch, and Sanpete Counties, and is known to exist throughout Salt Lake County (USDA NRCS 2006).

**Description**: Houndstongue is a biennial growing 1 to 4 feet (0.3 to 1.3 m) tall. It forms a rosette the first year and sends up a flowering stalk the second year. Leaves are alternate and range from 1 to 12 inches (2.5 to 25 cm) long, and are rough and hairy (resembling a hounds tongue), and lack teeth or lobes. Flowers are reddish-purple that bloom in early summer, and the fruit is composed of 4 prickly nutlets. The nutlets break apart at maturity and cling to clothing or animals; reproduction is solely by seed (Belliston et al. 2004).

**Control**: Grazing houndstongue, as a treatment option, is not possible. It is toxic, containing pyrrolizidine alkaloids that cause liver cells to stop reproducing. Animals may survive for six months or longer after they have consumed a lethal amount. Sheep are more resistant to houndstongue poisoning than are cattle or horses. Horses may be especially affected when confined in a small area infested with houndstongue and lacking desirable forage (Whitson et al, 1999). No other biocontrol options are available at this time. However, five biological control agents are being screened for their potential use on houndstongue. These include a root weevil *(Mogulones cruciger),* a seed weevil *(Mogulones borreginis),* a stem weevil *(Mogulones trisignatus),* a root beetle *(Longitarsus quadriguttatus)* and a root fly *(Cheilosia pasquorum).*

Herbicides can offer good to excellent control when applied between the rosette and bloom stages. Because this is a biennial, once it has set seed it is no longer susceptible to herbicide. The most effective chemical control is when picloram or 2,4-D is applied to the first year rosette stage killing nearly all plants; approximately three-fourths of the plants will die when sprayed the second year after bolting and flowering. Chlorsulfuron or metsulfuron applied when bolting plants are under 10 inches (25 cm) prevents seed production completely, are a better alternative for large stands with mixed phenological stages (USDA NISIC 2006).

Tilling or digging up the roots before seed development can offer good control. Flowering plants should be removed and bagged to prevent seed dispersal.

### 3.3.2.5 RUSSIAN OLIVE (*ELAEAGNUS ANGUSTIFOLIA*)

**Background**: Russian olive is originally from Europe, and was used as an ornamental in the United States. The fruits can be a valuable food source, and the tree often provides habitat for birds and wildlife. It grows well in meadows, pastures, and along waterways. Reproduction is from seed and rootstock, and thick stands can develop if left unchecked (Belliston et al. 2004). Russian olive has been identified as a noxious weed in Duchesne, Uintah, Carbon, Sevier, and Wayne Counties, but is a common weedy tree throughout Salt Lake County (USDA NRCS 2006).

**Description**: Russian olive is a small, usually thorny shrub or small tree that can grow to 25 feet (9 m) in height. Its stems, buds, and leaves have a dense covering of silvery to rusty scales. Leaves are egg or lance-shaped, smooth margined, and alternate along the stem. Highly aromatic, the initial creamy yellow flowers are later replaced by clusters of abundant silvery fruits. The twigs are flexible, coated with a gray, scaly pubescence and often have a short thorn at the end. The bark is thin with shallow fissures and exfoliates into long strips. It has a deep taproot and well-developed lateral root system (ISSG 2006).

**Control**: Adult male goats will graze the flowers, fruits, and leaves of Russian olive, but are limited in their accessibility to larger and taller vegetation. Apparently the most effective combination of control efforts has been cutting trees, followed by either spraying or burning the stumps. Russian olive is sensitive to 2,4-D ester, triclopyr, 2,4-D + triclopyr, imazapyr, and glyphosate. However, effective control with these compounds almost always requires follow-up treatments for 1 to 2 years. 2,4-D ester is applied to the foliage. It requires good coverage for acceptable results. 2,4-D + triclopyr is applied either as a foliar spray or a directed spray to the basal bark of the tree. Triclopyr is applied as a directed spray to the basal bark of the tree. Basal applications require good saturation of the bark and diesel fuel is frequently used as the carrier. Imazapyr is applied undiluted to frill cuts made in the stem. Glyphosate is also applied to frill cuts. Glyphosate has provided very good control when applied during the winter months (ISSG 2006).

### 3.3.2.6 DALMATIAN TOADFLAX (*LINARIA DALMATICA*)

**Background**: Dalmatian toadflax was brought to the United States from Europe, probably for ornamental purposes. It prefers rangeland and roadside habitat with sandy soils. It is very aggressive and hard to control due to deep roots and thick waxy leaf cuticle (CSU 2000). Dalmatian toadflax is recognized as a noxious weed in Tooele, Rich, and Wasatch Counties, and has been identified in Salt Lake County (USDA NRCS 2006)

**Description**: Dalmatian toadflax can be easily identified by its bright-yellow snapdragon shaped flowers, and can be distinguished from yellow toadflax by its larger flowers and more ovate leaves. The flowers of this plant are

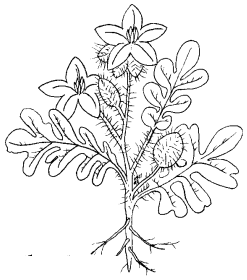
borne in loose, elongate racemes. Fruits are egg-shaped to nearly round capsules, and seeds are sharply angular and slightly winged. Leaves are broad, ovate, and alternate. Mature plants are up to 3 feet (1 m) tall (CSU 2000).

**Control**: Sheep and goats are very effective against dalmatian toadflax because they prefer it to other rangeland grasses. This will not kill the plant, but will keep it from flowering if the grazing regime is continued over the summer.

Tilling can be effective if done repeatedly. The cut roots can resprout resulting in a larger problem if not tilled again immediately when new sprouts are coming through the soil. This may need to be repeated 3-4 times per season for several years to deplete the root reserves as well as the soil seed bank (Whitson 1999).

Two rangeland herbicides, picloram and chlorsulfuron applied after a burn, have been shown to successfully reduce dalmatian toadflax. Chlorsulfuron applied in the fall or spring, or picloram applied in the spring effectively controlled Dalmatian toadflax for about three years leaving nutrients released by fire to desirable species (Jacobs and Sheley 2005). Studies of herbicide application for perennial weed control indicate the best time for application is when carbohydrate reserves in the underground portions are lowest. Reserve carbohydrates of Dalmatian toadflax are at their highest levels in the fall at the end of the growing season, and at their lowest point at the beginning of flowering in May (ISSG 2006).

### 3.3.2.7 BUFFALOBUR (*SOLANUM ROSTRATUM*)



**Background**: Buffalobur, or Texas thistle, is native to the United States, but can be very invasive infesting disturbed areas such as corals, gardens, pastures, and waste areas. Although not a state-listed noxious weed, it is listed in nearby Davis County, and is known to exist throughout Salt Lake County (USDA NRCS 2006). It grows in most soil types but prefers sandy soils. It is drought resistant making it competitive with other less drought tolerant species, but can also be outcompeted by many desirable species (Belliston et al. 2004).

**Description**: This annual grows 1 to 2 feet (0.5 to 0.75 m) tall with spines on stems, leaves, and seed heads. Leaves are heavily lobed, 2 to 5 inches (5 to 12 cm) and have prominent veins. Flowers are yellow with five lobes that flower throughout the summer, and the black, wrinkled, and flattened seeds are enclosed in an enlarged spiny calyx. After the plant has matured, it breaks off at the stem allowing it to blow around like a tumbleweed spreading thousands of seeds (Arnow et al. 1980)

**Control**: There is no biological control at this time for Buffalobur. It contains the alkaloid solanine, which is poisonous to livestock. Digging or removing this weed can provide good control, or cutting or mowing in conjunction with herbicide application. The most effective method of control is to treat with 2,4-D after mowing or cutting before the plant blooms (Whitson 1999).

### 3.3.2.8 TAMARISK (*TAMARIX RAMOSISSIMA*)

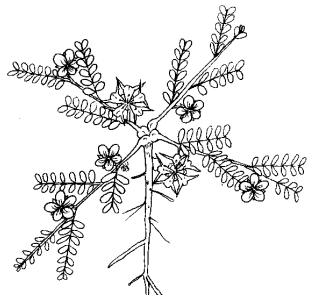
**Background**: Tamarisk is an aggressive, woody invasive plant that has become established over as much as a million acres of the western United States. Tamarisk crowds out native stands of riparian and wetland vegetation. It increases the salinity of surface soil, rendering the soil inhospitable to native plant species. Tamarisk provides generally lower wildlife habitat value than native vegetation, and uses more water than comparable native plant communities. These plants can widen floodplains by clogging stream channels and increase sediment deposition due to the abundance of tamarisk stems in dense stands (CSU 2000). This species is only listed as a noxious weed in Uintah County, although it present in water corridors and waste areas throughout the state of Utah.

**Description**: This deciduous loosely branched shrub has whitish or pinkish flowers borne on slender racemes. The leaves are minute, appressed and scaly. The primary root can grow to a depth of up to 100 feet (30 m) or more, and horizontal roots develop that spread after reaching the water table (CSU 2000).

**Control**: This tamarisk leaf beetle (*Diorhabda elongata*) has had tremendous success in the Great Basin controlling tamarisk by defoliating the plant. The third instar larvae and sometimes adult may kill more foliage than they eat by scraping the bark on small twigs. Defoliated plants suffer severe stem dieback but plants resprout from the base, but heavy defoliation after two years can kill acres of plants. When food becomes scarce, adults will fly to feed and lay eggs on nearby uninfested plants (Coombs et al. 2004). Currently, the tamarisk leaf beetle is available in Utah primarily in Delta and Moab. Best results are achieved if adult beetles are gathered in July and allowed to lay eggs in the new location before winter. Because of the massive bird and ant predation on the beetles, it is recommended that large populations (10,000 individuals) are introduced at one time (Burningham, personal communication).

A variety of herbicides have been used to manage tamarisk, and include picloram, glyphosate, and 2,4-D. These are generally applied as cut-stump treatments, although foliar, stem-sprout, root-sprout, injection, frill, and broadcast applications are used as well. When cut-stump treatments are used, the herbicide should be in a non-evaporative base so that the stump does not dry out before the chemical has entered (ISSG 2006).

### 3.3.2.9 PUNCTUREVINE (*TRIBULUS TERRESTRIS*)



**Background**: Puncturevine was first reported in California in 1903, and probably contaminated the wool of sheep imported from the Mediterranean region. This plant is widespread throughout the west, and is most often found in croplands, pastures, corrals, and along transportation rights-of-way. The spiny burs can cause injury to the mouths and digestive tracts of livestock (Coombs et al. 2004). Puncturevine has been identified as a noxious weed in Cache, Weber,

and Morgan Counties, and is known throughout Salt Lake County (USDA NRCS 2006).

**Description**: Puncturevine is a prostrate, herbaceous annual. The root system of puncturevine consists of a simple taproot branching into a network of fine roots. The prostrate stems radiate out from the root crown to form a mat. The hairy stems often grow to 6 feet (2 m) long, and are green to reddish in color. The small yellow flowers appear between June and September, and are produced in the leaf axils. The spiny fruits are made up of five burs with two spines each that break apart at maturity, and each bur contains two to four seeds (Belliston et al. 2004).

**Control**: This plant has been controlled with biological control agents in areas without cold winters. The puncturevine seed weevil (*Microlarinus lareynii*) may produce multiple generations in warm climates. The larvae develop inside the fruits where they feed on the seeds, and the adults emerge and begin to feed upon the stems, leaves, flowers, buds, and fruits. Similarly, the puncturevine stem weevil (*Microlarinus lypriformis*) may produce multiple generations in warm climates. The larvae mine the stems and root crowns of the plants, while the adults feed on leaves and the undersurface of the stems. Both weevils are readily available, and can be collected from the soil litter beneath plants. The best control is provided when both the puncturevine seed weevil and stem weevil are used together. Damage to nontarget plants is not a problem for either species (Coombs et al.2004).

Picloram, applied as a pre-emergence spray, can give adequate, but not complete control. The spraying of young plants with amitrole, cholsulfuron, or 2,4-D may also be desirable (CSU 2000).

## 3.3.3 Non-listed Invasive Species

### 3.3.3.1 CHEATGRASS (*BROMUS TECTORUM*)

**Background**: Cheatgrass can greatly alter the species composition of dry native rangeland vegetation by competitive exclusion or reproduction of native plant species and the facilitation of wildfires. Whereas the invasion of cheatgrass is greatest in drier environments, it is common in all lowland areas in the arid and semi-arid west. Disturbance, such as heavy grazing, allows cheatgrass and other annuals to invade and proliferate. The dry stands of cheatgrass increase fire frequency creating an environment dominated by cheatgrass (CSU 2000).

**Description**: Cheatgrass is a winter annual grass. The flower has loose, irregularly compound flowering parts with flowers borne on individual stalks. The panicles change color from green to purple to brown as the plant matures and eventually dries out. Branches are slender, drooping, and hairy with up to eight awned spikelets. Leaves are light green and hairy. Sheaths are fused except near the node at the bottom of each sheath. The lower sheaths are conspicuously hairy, while the upper sheaths are sometimes smooth. Mature plants are generally 4 to 30 inches (10 to 75 cm) tall (Belliston et al. 2004).

**Control**: Grazing can help control cheatgrass, and two grazing periods each spring are required for at least two consecutive years. Plants should first be grazed at the stage just before the inflorescences emerge, then grazed again before panicles emerge. Grazing intensity needs to be light enough to leave at least a 3-inch residual height to protect desirable grasses. Winter grazing of cheatgrass can reduce mulch, thereby hindering cheatgrass establishment and favoring perennial grass establishment in the spring (CSU 2000).

Cutting is not recommended as cut plants will produce new stems and seeds at the cut height. Burning is usually effective after the plant has dried, but before the seeds have dropped, however, some seeds will survive (CSU 2000).

There are several types of herbicides that can be used alone or combined to provide effective control. In most cases, herbicides should be applied in early spring when non-target species are dormant. The best control is when the plants are 4 inches (10 cm) or less and growing vigorously. Spring applied herbicides include quizalofop, fluazifop-p-butyl, sethoxydim, glyphosate, and imazapic. Fall herbicide applications should be conducted after downy brome seeds have germinated and are beginning to grow, and include sulfometuron methyl and metribuzin (CSU 2000).

### 3.3.3.2 COMMON TEASEL (*DIPSACUS FULLONUM*)

**Background**: Common teasel grows in open, sunny habitats that range from wet to dry. It is generally found along irrigation ditches, abandoned fields, pastures, waste places, and forests. It is spreading rapidly, and is know to be collected and spread as an ornamental decoration for dried flower arrangements.

**Description**: This biennial or sometimes perennial forb has purple flowers that are subtended by spiny, awned bracts. The fruits are four-angled, and each contains a single seed. The rosette leaves are conspicuously veined with stiff prickles on the lower midrib. Stem leaves are simple, opposite, net-veined, and clasp the stem. Flowering plants have large, oblong, opposite leaves that form cups, which are capable of holding water. Mature plants can grow up to 6 feet (2 m) tall. The taprooted stem is rigid and furrowed with rows of downward turned prickles (CSU 2000).

**Control**: A flea beetle, *Galleruca fuliginosa*, and the beetle, *Galleruca pomonae*, were found feeding on teasel in France. Both beetles are currently being tested for host specificity in field and greenhouse trials, but have not been released (Coombs et al. 2004). The key to controlling common teasel is to eliminate seed production and exhaust the seed bank in the soil. Common teasel does not reproduce vegetatively and dies after seed production. Therefore, cutting the stalks of flowering plants is recommended as the best control in natural areas. Cut stalks should be bagged and burned, and usually requires several years of control to deplete the soil seed source. Metsulfuron at 0.3 oz ai/acre will control teasel. Dicamba at a rate of 0.25 to 0.5 lb ai/acre can be applied on teasel rosettes less than three inches in diameter. For rosettes greater

than three inches, increase to 0.5 to 1.0 lb ai/acre, and apply 1.0 to 1.5 lb ai/acre when teasel is bolting (CSU 2000).

#### 3.3.3.3 PHRAGMITES (*PHRAGMITES AUSTRALIS*)

**Background**: Phragmites is a large perennial rhizomatous grass, or reed, forming monotypic stands in wetland areas. It is common in alkaline and brackish environments, and can also thrive in highly acidic wetlands. Growth is greater in fresh water, but it may be outcompeted in these areas by other species. It can survive in stagnant waters where the sediments are poorly aerated by providing the underground parts of the plant with a relatively fresh supply of air from the air spaces in the aboveground stems and rhizomes. The build up of litter from the aerial shoots within stands prevents or discourages other species from germinating and becoming established. The rhizomes and adventitious roots themselves form dense mats that discourage annual and perennial native establishment. Killing frosts may knock the plants back temporarily, but can ultimately increase stand densities by stimulating bud development (CSU 2000).

**Description**: The plants generally flower and set seed between July and September, and may produce great quantities of seed. However, some or most of the seed produced is not viable, and most reproduction results from rhizomes (TNC 2006). Individual rhizomes live for 3 to 6 years and buds develop at the base of the vertical tip late in the summer each year. These buds mature and typically grow about 3 feet (1 m) before terminating in an upward apex and going dormant until spring. The apex then grows upward into a vertical rhizome that in turn produces buds that will form more vertical rhizomes. Vertical rhizomes also produce horizontal rhizome buds, completing the vegetative cycle. These rhizomes provide the plant with a large absorbent surface that brings the plant nutrients from the aquatic medium. The aerial shoots arise from the rhizomes. They are most vigorous at the periphery of a stand where they arise from horizontal rhizomes, as opposed to old vertical rhizomes. Germination is not affected by salinities below 1%, but declines at higher salinities. Following seed set, nutrients are translocated down into the rhizomes and the aboveground portions of the plant die back for the season (Belliston et al. 2004).

**Control**: The only biological control at this time is grazing by cattle or goats. Naturally occurring parasites have not proven to be successful control agents. Coots, nutria, and muskrats may feed on phragmites, but appear to have limited impacts on its populations. Burning is only successful if root burn occurs, but rarely happens because a layer of soil or mud usually covers the rhizomes. Flooding can be used to control phragmites when 3 feet of water covers the rhizome for an extended period during the growing season, ideally for up to four months. However, flooding could also destroy communities of desirable plants.

Rodeo® with a surfactant that allows it to stick to and subsequently be absorbed by the plant is commonly used for phragmites control. This herbicide is not, however, selective and will kill grasses and broadleaved plants alike, although it is virtually non-toxic to all aquatic animal tested (TNC 2006). Application must take place after tasseling stage in the fall when the plant is supplying nutrients to the rhizome. At this time, when Rodeo® is sprayed onto the foliage of phragmites, it translocates into the roots and interferes with essential plant growth processes, causing gradual wilting, yellowing, browning and deterioration of the plants. The dead reeds are

resistant to decomposition, and require physical manipulation to allow native plant species to reestablish following spraying (CSU 2000).

#### 3.3.3.4 MYRTLE SPURGE (*EUPHORBIA MYRSINITES*)

**Background**: Myrtle spurge, also known as donkey tail or creeping spurge, was introduced as a common garden plant in xeric landscapes that escaped cultivation. Its milky sap can cause significant skin and eye irritations. It does not tolerate cultivation, and therefore is found in rangelands, pasturelands, roadsides, and wastelands. It prefers well-drained, part to full sun, and has been listed as a noxious weed in several states (USDA Plants 2006)

**Description**: Myrtle spurge is a low growing perennial reaching 4 to 6 inches (10 to 15 cm) tall, with new stems originating from the taproot each spring. The stem leaves are fleshy, blue-green, alternate, appearing spirally arranged. Inflorescences are umbels with small inconspicuous flowers subtended by yellow bracts that appear from March to May. Myrtle spurge reproduces entirely from seed.

**Control**: This species is not yet widespread in Utah, and should be a priority for immediate eradication if found. Early detection and removal of this plant offer the most simple and cost efficient method of control for myrtle spurge, although plants must be removed for several years in a row. It is important to remove the taproot, and all flowers should be bagged or burned as the seeds can continue to mature after the plant has been cut. No known biological controls are available at this time, and there is some evidence of toxicity to cattle, although most grazers tend to avoid it.

The herbicides 2,4-D, dicamba, and glyphosate can be effective against myrtle spurge, but a surfactant must be used to ensure the herbicide adheres to the waxy cuticle. Picloram is another possible control. The seedling stage is generally the best time to apply herbicides (CSU 2000).

#### 3.3.3.5 ALYSSUM (*ALYSSUM MINUS*)

**Background**: Plants in the Alyssum genus are native to Europe, Asia, northern Africa, and the Mediterranean region. They are now found throughout the globe in temperate regions.

**Description**: Alyssum minus is a short, early season annual and a member of the Brassicaceae family. It is a prolific seed producer and is capable of outcompeting other species over large areas. It prefers disturbed sites.

**Control**: Princep applied as a pre-emergent control is effective. Chlorsulfuron and imazapic are the most effective post-emergent herbicides for members of the Brassicaceae family.

#### 3.3.3.6 BURDOCK (*ARCTIUM MINUS*)

**Background**: Burdock is common throughout the world, but most likely originated in Europe and Asia. Its Velcro-like spines allow it to be transported on fur and clothing. It has been used

for centuries for its medicinal and edible qualities, and human-introduced populations may have contributed to its wide range.

**Description:** A biennial plant, having first year basal leaves that are large (over 12 inches across) and second year stems that can reach 5 to 10 feet. Seed heads have long hooked bracts that attach to fur and clothing.

**Control:** First-year rosettes are easily controlled using herbicides with 2,4-D. Mature plants can be controlled by manual removal before flowers and burs are formed. Efforts will most likely have to be repeated during the growing season, as the plants tend to regenerate from an extensive taproot.

#### 3.3.3.7 MULLEIN (*VERBASCUM THAPSUS*)

**Background**: There are many different species of this genus, most of which originated in Europe (particularly the Mediterranean area). It has been cultivated historically for a wide range of medicinal and other uses, and human introduction has most likely contributed to its spread.

**Description:** Mullein is a biennial plant that produces a rosette of gray-green leaves covered with a soft pubescence. In its second year it sends up a flower stalk that can reach up to 6 feet.

**Control:** Mechanical removal is effective, as the plant will not regenerate from its taproot. Because mullein seedling emergence is dependent on the presence of bare ground, sowing sites with early successional native grasses or other plants may decrease seed germination and the chance of successful emergence of mullein seedlings.

Two insects are known that may have implications for biological control of mullein. The European curculionid weevil (*Gymnaetron tetrum*), which has been determined to be specific to mullein, and the mullein moth (*Cucullia verbasci*) have both been introduced to the U.S. Larvae of the weevil mature in the seed capsules and cause significant damage to the seeds.

Herbicidal control is an effective option for situations where hand pulling of plants is not practical. Glyphosate should be applied in a 2% solution of triclopyr and water plus a non-ionic surfactant.

#### 3.3.3.8 COCKLEBUR (*XANTHIUM STRUMARIUM*)

**Background**: Cocklebur is a native to the Americas and southeast Asia, but is now found throughout the globe. Its spiny burs allowed it to be distributed by clothing and fur.

**Description:** Cocklebur is an annual weed species. Since seeds germinate best after having been soaked in water, it is commonly found in ephemeral ponds or along waterways. The plants are usually between 1 to 2 feet tall, with heart-shaped leaves. A cluster of oval, prickly burs about 3/4 inch long occur on a terminal spike.

**Control:** Herbicide treatment of cocklebur is possible. Glyphosate, dicamba, or atrazine applied at post-emergence can be highly effective.

Biological control by grazing is not recommended, as several compounds found in the plant and seed tissue are highly toxic to animals.

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## 4.0 MANAGEMENT GOALS AND OBJECTIVES

The focus of weed control is only part of the overall holistic site management and restoration program. Instead, focusing on increasing desirable plant species, in conjunction with eliminating and/or reducing weed populations is more effective. Preventative programs should include keeping the site free of species that are not yet present, but are known to be in the general vicinity of the property. Priority weed treatment areas should be determined in order to control or eliminate weeds that are established on the property, according to their actual and potential impacts on native species and communities, their visual impact, and fire danger. Action should only be taken when careful consideration indicates leaving the weed populations unchecked will result in more damage than controlling them using available methods.

Preventing new infestations and prioritizing treatment of existing infestations are top priorities of this plan. We will also consider the difficulty of control; giving higher treatment priority to infestations that is more receptive to available technology and resources, and will also reduce species that exist within those larger infestations. The overall goal of this plan is to restore LNP property to a mosaic of healthy, native ecosystems by reducing the negative influence of weeds on native plants and wildlife and increasing native plant species biodiversity and abundance. This goal will be accomplished by meeting the following objectives.

1. Minimize establishment of new weed species,
2. Comply with existing weed control laws,
3. Seed weedy areas with desirable native plant species
4. Accomplish weed control without significant adverse environmental effects,
5. Reduce impacts of weed infestations on adjacent lands

Specific locations within the LNP complex have been identified as priority treatment areas based upon numerous criteria. For ease of implementation, the property has been divided into management areas based on elevation, habitat, and vegetation characteristics using information obtained from personal observations and SWReGAP vegetation analysis (USGS 2004). Part of the wetland area adjacent to the Great Salt Lake is part of the 3,670-acre Inland Sea Shorebird Reserve (ISSR), a mitigation wetland created by Kennecott in 1996, and is currently managed for weeds. Aside from the ISSR, the northern portion of the property consists of alkaline soil with grasslands and scattered shrublands, and is where numerous supporting facilities and operations exist. The eastern low elevation foothills and toe slopes were used for agriculture and grazing, and consist of grasslands and desert shrubs. Many supporting industrial areas are found in this region, including previous reclamation sites. The mid elevation foothills support submontane shrub and grassland areas, and a small juniper section below the mine near Midas Gulch. The high elevation sites are vegetated with conifer and aspen stands. The mine is located at the southern end of the property in both the mid and upper montane vegetation types. High priority areas identified by LNP including the Visitors Center, supporting buildings and infrastructure, and transportation and riparian corridors, and are addressed individually to capture their unique characteristics and management opportunities.

Management goals also need to be defined for specific areas or projects. They should include statements that are specific, measurable and achievable, have a deadline, and are location specific. These goals provide a link between overall property goals mentioned above, and specific action steps. An example that may be used for the property surrounding the Visitor's Center is illustrated below.

1. Provide opportunities for public and worker education through signs and training.
2. Identify and protect cultural and historical resources.
3. Eliminate noxious and invasive weeds from the one-acre area that surrounds the Visitor's Center within two years.
4. Establish native shrubs, bunchgrasses, and forbs in the one-acre area that surrounds the Visitor's Center within three years using transplants and seeding.
5. Reduce the abundance of dalmatian toadflax and cheatgrass in the five-acre area that surrounds the Visitor's Center by one-half over the next five years.
6. Establish native shrubs, bunchgrasses, and forbs in the five-acre area that surrounds the Visitor's Center within five years using seeding.
7. Identify and eliminate all myrtle spurge individuals in the five-acre area that surrounds the Visitor's Center within one year.
8. Eradicate any new infestations of noxious or invasive weeds within one year of their discovery in the five-acre area surrounding the Visitor's Center.

Other goals and objectives that would be appropriate for LNP property include the following.

1. Reduce the abundance of Dyer's Woad along rail corridors.
2. Identify alternative water sources for cattle away from sensitive riparian areas.
3. Eliminate noxious and invasive weeds on LNP property that appear within 100 feet of Highway 111 or I-80.
4. Eliminate all cheatgrass within 100 feet of any LNP building or facility.
5. Develop training program for LNP personnel within 2 years, and include weed identification, reporting, and prevention.

# 5.0 WEED CONTROL FOR MANAGEMENT AREAS (MAS)

Mapping is the first step in noxious weed management in identifying problem areas, and allows for monitoring the level of success of control measures. The 2006 baseline mapping effort occurred from April through June, and rendered an approximate coverage of weeds present at the time of the survey. Because the 2006 mapping covered such large areas, some areas observed as low percent cover (6-10%) would be classified as medium or high (11-25% or 26-50%) at a later date due to the phenological stage of the plants. These changes in cover were observed and recorded, but not quantified because it was not possible to conduct subsequent mappings. Therefore this analysis is using the plant cover recorded at the time of the survey with the caveat that these values may be conservative. Mapping can be staged in subsequent years to capture plant populations at more mature stages in order to refine the percent cover data now that the general extent of infestations is mapped. The following sections show the acreage of infestation mapped in 2006 by MA, and each MA is addressed separately for the ease of management implementation.

## 5.1 RANKING NOXIOUS WEEDS

Noxious weed species were numerically ranked using four specific invasion categories: invasiveness, ecological impact, occurrence in habitats, and controllability. Within each category, each species was given a rank of 1 to 4, with 4 being the highest, or most difficult to control. If a species was described by more than one criterion in a given category, it was assigned the highest priority (e.g., 4 points). The highest ranking species would receive a maximum score of 16, and identified as priority species. The rankings were used to discern the priority weed species and to sort priorities into 4 classes (Table 2). Ranking descriptions are as follows:

Invasiveness:

1. Species not yet on the site but which are present nearby.
2. Species present as new populations or outliers of larger infestations, especially if they are expanding rapidly.
3. Species present in large infestations that are not expanding, either unaided or due to control efforts.
4. Species present in large infestations that continue to expand.

Ecological Impact:

1. Species that do not outcompete dominant desirable plants but rather coexist.
2. Species that do not outcompete dominant desirable plants but:
   a. prevent or depress recruitment or regeneration of desirable species OR
   b. reduce or eliminate resources (e.g., food, cover, nesting sites) used by desirable animals; OR

   c. promote populations of invasive non-native animals by providing them with resources otherwise unavailable in the area.
3. Species that overtake and exclude desirable plants following natural disturbances thereby altering succession, or that hinder restoration of natural communities.
4. Species that overtake and exclude desirable plants without natural disturbances and can invade and establish in otherwise pristine ecosystems.

Occurrence in Habitat:

1. Species that occur in upland areas.
2. Species that occur in wet meadow areas (either fresh water or salt-affected meadows).
3. Species that occur in the alkaline knolls and evaporative basin areas.
4. Species that occur in standing water or at the waters edge.

Controllability:

1. Species likely to be controlled or eliminated with available technology and resources, and which desirable plants species will re-establish with little further input.
2. Species likely to be controlled but will not be replaced by desirable plants without an active restoration program requiring substantial resources.
3. Species difficult to control with available technology and resources and/or whose control will likely result in substantial damage to other, desirable species.
4. Species unlikely to be controlled with available technology and resources.

Class descriptions are as follows:

1. Contain/Reduce: Weeds that occur in both large and small patches, and have the greatest visual, economic, and environmental impacts. These weeds occur across large acreages and widespread effective control is imperative for the restoration of critical habitat. The weed control goal on these sites is to contain the existing weed populations, and reduce the acreage inhabited by these weeds.
2. Contain/Eradicate: Weeds that are abundant in scattered patches throughout the LNP. However, without intervention, it is possible these weed populations will expand to incorporate additional land and become Class 1 problem weeds. The weed control goal for Class 2 weeds is to contain the small populations, and eradicate them before they have an opportunity to spread.
3. Prevent/Eradicate: Weeds that occur in very small infestations, often a single plant, but still have the potential to spread rapidly. Control efforts are very cost effective with this class. The weed control goal on these sites is to prevent the establishment of these weed species and eradicate existing plants.
4. Monitor/Prevent: Weeds that may not occur on the LNP at this time, or are not regarded as being a serious problem in this area at this time. The weed control goal for these species involves continual monitoring to identify potential new weed species, and prevent them from establishing in the LNP.

The ranking of noxious weed species provides guidance regarding how best to use available resources to control noxious weeds while minimizing negative impacts to desirable species. Efforts directed toward these species, such as goat grazing or herbicide, will indirectly affect species that presently are not of critical concern. For example, phragmites eradication is a priority along the waters edge, and the use of goats has been successful in reducing biomass. Meanwhile, other species such as teasel and purple loosestrife are present in these areas and will be subjected to the goat grazing pressure. Similarly, identifying species that exist in small patches requires more specific efforts, such as a backpack spayer or physical removal of a few individuals. These strategies will be addressed further in Section 5.0, Weed Control for Management Areas (MAs).

**Table 2. Weed Control Strategies for Priority Noxious Weed Species on the LNP**

| Common Name | Invasiveness | Ecological Impact | Occurrence in Habitats | Controllability | Total Score |
|---|---|---|---|---|---|
| ***Class 1: Contain/Reduce*** | | | | | |
| Phragmites | 4 | 4 | 4 | 4 | 16 |
| Hoary cress | 4 | 4 | 4 | 4 | 16 |
| Perennial pepperweed | 4 | 4 | 4 | 4 | 16 |
| Russian olive | 4 | 4 | 4 | 4 | 16 |
| Tamarisk | 3 | 4 | 4 | 4 | 15 |
| ***Class 2: Contain/Eradicate*** | | | | | |
| Teasel | 3 | 3 | 4 | 4 | 14 |
| Field bindweed | 4 | 3 | 3 | 2 | 12 |
| Purple loosestrife | 2 | 3 | 4 | 3 | 12 |
| Poison hemlock | 2 | 3 | 4 | 3 | 12 |
| Dalmatian toadflax | 2 | 4 | 2 | 3 | 11 |
| Russian knapweed | 2 | 4 | 3 | 2 | 11 |
| ***Class 3: Prevent/Eradicate*** | | | | | |
| Canada thistle | 3 | 3 | 2 | 2 | 10 |
| Scotch thistle | 2 | 3 | 2 | 3 | 10 |
| Musk thistle | 2 | 3 | 2 | 2 | 9 |
| Dyer's woad | 2 | 3 | 1 | 2 | 8 |
| **Class 4: Monitor/Prevent** | | | | | |
| Johnsongrass | 1 | 3 | 4 | 3 | 11 |
| Buffalobur | 1 | 3 | 2 | 4 | 10 |
| Quackgrass | 1 | 3 | 3 | 3 | 10 |
| Yellow nutsedge | 1 | 3 | 3 | 3 | 10 |
| Bermudagrass | 1 | 3 | 1 | 4 | 9 |
| Diffuse knapweed | 1 | 3 | 2 | 3 | 9 |

**Table 2. Weed Control Strategies for Priority Noxious Weed Species on the LNP**

| Common Name | Invasiveness | Ecological Impact | Occurrence in Habitats | Controllability | Total Score |
|---|---|---|---|---|---|
| Squarrose knapweed | 1 | 3 | 1 | 4 | 9 |
| Yellow starthistle | 1 | 3 | 1 | 4 | 9 |
| Leafy spurge | 1 | 4 | 1 | 2 | 8 |
| Medusahead | 1 | 4 | 1 | 2 | 8 |
| Puncturevine | 1 | 2 | 2 | 3 | 8 |
| Spotted knapweed | 1 | 3 | 1 | 2 | 7 |

## 5.2 ALKALINE FLATS & SLOPE WETLANDS MA

Hoary cress and perennial pepperweed occupy over 50% of the 852-acre Alkaline Flats & Slope Wetlands MA. These Class 1 weeds are often found together, but may also form monotypic stands covering up to 70-acre patches. With areas this large, it is imperative that aggressive control methods be used against these weeds. Hoary cress contains a chemical compound that inhibits iodine absorption in goats. To accommodate this, goats were grazed on patches with mixed vegetation of hoary cress and perennial pepperweed or intermediate wheatgrass, or supplemented with iodine within the wetter and riparian areas of this Management Area in the spring of 2006. In the upland areas that were not grazed, the herbicide 2,4-D was applied in the early spring before seed set. Continuing efforts against these infestations are critical to contain and reduce both hoary cress and perennial pepperweed.

Perennial pepperweed is found throughout this MA in all habitat types. The spring application of 2,4-D and dicamba may have had some effect on this species, although 2,4-D is not effective and dicamba's effectiveness is greatly increased by disking in the fall and mowing in the spring. For perennial pepperweed monocultures, greater control is achieved if perennial pepperweed infestations are disked in the fall to fragment roots. The plants will resprout but will not have the extensive root system and subsequent resources to draw on the following spring. These newly sprouted plants should then be mowed in the spring between the flowerbud and flowering stage. Again, plants will resprout but with limited ability to rely on root reserves, approximately two to three weeks following mowing depending on soil moisture. Newly resprouted leaves will be larger and parallel to the ground, opposed to the smaller leaves that are perpendicular to the ground on unmowed perennial pepperweed plants. These leaves provide a greater surface area to intercept and absorb herbicide, and more of the herbicide is translocated to the small fragmented rooting structures. Following these treatment methods can provide complete control within one year (TNC 2006). The area should be revegetated immediately with desirable grasses to increase competition with perennial pepperweed, and reduce the risk of other invasive species from establishing in the area.

Phragmites occupies 0.96 ac from four different locations. The largest infestation, 0.86 ac, was centrally located along the eastern boundary of the MA. This area had standing water at the time of the survey, and may be considered important habitat for aquatic species. Similarly, a linear

segment, 0.09 ac, on the western boundary of the MA follows an ephemeral ditch that may also provide aquatic habitat. Two smaller infestations were identified along the roadside that likely receives additional moisture from runoff; teasel was also found in these roadside locations. Because of the proximity to water, it is important to use appropriate controls in these areas. Goats were released into this area in the fall of 2006 when the water level was reduced to accommodate the needs of the goats; they will not enter deep water to graze. No herbicide was applied to phragmites.

Similar to phragmites, tamarisk is often located near open water and subsequent aquatic habitat. Most of the infestations were located in the northern portion of the MA. Small distinct populations or single individuals were identified and mapped in 2006 providing an opportunity to address these individuals and reduce the possible spread to other areas. Goat grazing may stress new shoots in this area reducing their ability to establish. The tamarisk beetle has been released south of the LNP in the Inland Sea Shorebird Reserve (ISSR), and individuals may migrate north onto the property. Gathering adult tamarisk beetles from the ISSR in July or August and releasing them in subsequent years could provide cost-effective and efficient biological control. Alternatively, cutting tamarisk and painting herbicide on the cut stumps within 30 minutes to ensure the translocation to the roots would eliminate these few individuals as a seed source.

Dalmatian toadflax occupies 0.01 acres from sites near the western border with the Evaporative Basin MA. No other Class 2 weeds were identified in this MA. These small occurrences are critical to eradicate to reduce the possibility of expansion. Physical removal or a backpack sprayer with picloram and chlorsulfuron in spring when carbohydrate root reserves are lowest may prove to be the most successful for individual plants and small infestations.

**Table 3. Weed Species in the Alkaline Flats & Slope Wetlands MA**

| Weed Species | Acres Occupied |
|---|---|
| Hoary cress | 456.37 |
| Perennial pepperweed | 23.91 |
| Teasel | 3.27 |
| Phragmites | 0.96 |
| Tamarisk | 0.07 |
| Scotch thistle | 0.04 |
| Dalmatian toadflax | 0.01 |
| Russian olive | 0.01 |
| **Total** | **484.64** |

## 5.3 RIVERINE MA

The Riverine MA comprises large patches of hoary cress in both monotypic stands as well as stands associated with other weed species. Similar to other MAs, these stands need to be

aggressively treated with both biological and chemical controls. Goats were grazed in this area in early spring to reduce biomass and prevent seed set. The mixed vegetation stands provided goats with alternative forage that helped reduce the iodine deficiency associated with hoary cress; perennial pepperweed is co-dominant with hoary cress in most of the weed infestation in this MA. In monotypic stands of hoary cress, the goats required iodine supplements.

Russian knapweed was identified in the southern portion of the MA. This was the only area where Russian knapweed was located in substantial quantities on the LNP, and should be aggressively controlled to prevent further invasion. Similarly, a small infestation of dalmatian toadflax was identified near the Russian knapweed. Because this area was inundated with water in the spring, the herbicide 2,4-D was applied in the fall of 2006 in areas away from riparian areas. Additionally, goats were grazed on the riverbank away from the herbicide application.

To address this Russian knapweed infestation, treatment controls should include mowing, herbicide application, and seeding. Mowing followed by applying picloram in the fall removes living Russian knapweed biomass and enables the herbicide to reach to soil surface, its intended target. This will then move into the plant root zone where it will attack and kill existing Russian knapweed plants, as well as target new plants in the spring (Carpinelli et al. 2003). However, picloram resides in the soil, and may not be suitable for this area. A combination of clopyralid plus 2,4-D provides good control when applied at the flowering stage in the spring, and is less effective when applied at the rosette or flowerbud to flowering stage (Laufenberg et al.2005). Applying 2,4-D plus clopyralid has the added benefit of not targeting grasses, and can be applied in the spring following a seeding treatment with desirable perennial grasses in the fall (Laufenberg et al.2005).

The area surrounding the Russian knapweed infestations is largely composed of hoary cress. This species is very difficult to control, and requires a combination of treatment methods in conjunction with reseeding to establish a perennial stand that will compete with hoary cress for resources. The best control against hoary cress is achieved when treatment occurs in the spring, but fall is the optimal time to attack Russian knapweed. Because Russian knapweed is a recent addition to the LNP, it should be addressed first. Fall treatments are available against hoary cress, and combining efforts against these two species is the most cost effective.

Picloram provides the greatest control against Russian knapweed, but does not control hoary cress. Metsulfuron or chlorsulfuron control hoary cress, but are not as effective against Russian knapweed. Dicamba has been shown to be effective against both of these species, and was sprayed along with 2,4-D in this area, targeted at Russian knapweed populations, on April 26, 2006. The hoary cress population near the south road entrance gate was spot treated with metsulfuron on October 23, 2006. Having treated both of these weed species in 2006 provides an ideal opportunity for reseeding and revegetation with desirable perennial grasses.

A broadcast seeding event followed by harrowing to cover the seeds with soil in the winter of 2006 would help reduce the dominance each of these species currently maintains. Additional species in this location that were likely affected by herbicide application, and would benefit greatly by revegetation include perennial pepperweed and dalmatian toadflax.

Perennial pepperweed is found throughout this MA in all habitat types. The spring application of 2,4-D and dicamba may have had some effect on this species, although 2,4-D is not effective and dicamba's effectiveness is greatly increased by disking in the fall and mowing in the spring. For perennial pepperweed monocultures, greater control is achieved if perennial pepperweed infestations are disked in the fall to fragment roots. The plants will resprout but will not have the extensive root system and subsequent resources to draw on the following spring. These newly sprouted plants should then be mowed in the spring between the flowerbud and flowering stage. Again, plants will resprout but with limited ability to rely on root reserves, approximately two to three weeks following mowing depending on soil moisture. Newly resprouted leaves will be larger and parallel to the ground, opposed to the smaller leaves that are perpendicular to the ground on unmowed perennial pepperweed plants. These leaves provide a greater surface area to intercept and absorb herbicide, and more of the herbicide is translocated to the small fragmented rooting structures. Following these treatment methods can provide complete control within one year (TNC 2006). The area should be revegetated immediately with desirable grasses to increase competition with perennial pepperweed, and reduce the risk of other invasive species from establishing in the area.

Both the spring application of dicamba and the fall application of metsulfuron are effective against this weed; 2,4-D does not provide an effective control.

The Jordan River corridor was infested with a variety of weeds, including hoary cress, Scotch thistle, poison hemlock, and Russian knapweed. Approximately three acres of this linear area was mapped in the spring of 2006, and a larger area was not mapped due to flooding and bald eagle buffer constraints. This linear segment most likely continues north and west through the Riverine MA and connects to the linear segment mapped in the Evaporative Basin MA. These areas must be carefully treated due to the proximity to water and the associated aquatic and bird habitat, as well as the bald eagle buffer. Coordination with USFWS is necessary to determine the best management alternatives for this area to avoid disturbing the bald eagles during nesting and fledging seasons, such as allowing goats into this area without the herders or dogs. Otherwise, removal of dead plant material and reseeding with desirable seed is another option that may be considered.

**Table 4. Weed Species in the Riverine MA**

| Weed Species | Acres Occupied |
|---|---|
| Hoary cress | 78.03 |
| Perennial pepperweed | 8.92 |
| Russian knapweed | 0.93 |
| Tamarisk | 0.02 |
| Dalmatian toadflax | 0.01 |
| **Total** | **87.91** |

## 5.4 EVAPORATIVE BASINS MA

The Evaporative Basins MA is bounded on the west by the Jordan River, and the north by the State Canal. These perennial water sources, and the subsequent flooding of this area in the spring of 2006, resulted in large patches of Class 1 weed species: phragmites, tamarisk, and Russian olive. Linear segments of phragmites were mapped along a ditch running the length of the MA from north to south. Goats were grazed along this corridor in the spring of 2006 and successfully reduced biomass and subsequent seed production. Because of regeneration, goats will need to be grazed in this area again in the fall of 2006. As the plants use root resources for new biomass, they will be more susceptible to stress following the fall grazing. An appropriate aquatic herbicide application in the fall following grazing efforts may be efficient in combating this linear segment.

Numerous weedy species were identified along approximately 22 acres of the banks of the Jordan River, including hoary cress, perennial pepperweed, teasel, dalmatian toadflax, musk thistle, and purple loosestrife. Mapping of this linear corridor of weeds was not complete due to bald eagle buffer constraints and flooding at the southern end of the MA. However, it is likely the weeds continue south along the Jordan River, as numerous weeds were found along the riverbank in the Riverine MA upstream. Goats were grazed along the riverbank in the summer of 2006, and foraged heavily on phragmites and perennial pepperweed. Because they were unable to access this area until summer due to the high water and the bald eagle buffer, hoary cress had already senesced and set seed. An appropriate aquatic herbicide application, such as Rodeo®, on hoary cress in the spring would help combat this infestation.

Perennial pepperweed is found throughout this MA in all habitat types. The spring application of 2,4-D and dicamba may have had some effect on this species, although 2,4-D is not effective and dicamba's effectiveness is greatly increased by disking in the fall and mowing in the spring. For perennial pepperweed monocultures, greater control is achieved if perennial pepperweed infestations are disked in the fall to fragment roots. The plants will resprout but will not have the extensive root system and subsequent resources to draw on the following spring. These newly sprouted plants should then be mowed in the spring between the flowerbud and flowering stage. Again, plants will resprout but with limited ability to rely on root reserves, approximately two to three weeks following mowing depending on soil moisture. Newly resprouted leaves will be larger and parallel to the ground, opposed to the smaller leaves that are perpendicular to the ground on unmowed perennial pepperweed plants. These leaves provide a greater surface area to intercept and absorb herbicide, and more of the herbicide is translocated to the small fragmented rooting structures. Following these treatment methods can provide complete control within one year (TNC 2006). The area should be revegetated immediately with desirable grasses to increase competition with perennial pepperweed, and reduce the risk of other invasive species from establishing in the area.

**Table 5. Weed Species in the Evaporative Basins MA**

| Weed Species | Acres Occupied |
|---|---|
| Hoary cress | 62.95 |
| Bull thistle | 2.20 |
| Perennial pepperweed | 2.09 |
| Teasel | 1.54 |
| Phragmites | 0.56 |
| Tamarisk | 0.01 |
| **Total** | **69.35** |

## 5.5 FARMINGTON BAY MA

The Farmington Bay MA is the most northern portion of the property. It is adjacent to the Farmington Bay Waterfowl Management Area that has been actively managed for noxious and invasive weeds. Perhaps as a result, this area has fewer acres of noxious weeds compared to the southern portion of the LNP.

**Table 6. Weed Species in the Farmington Bay MA**

| Weed Species | Acres Occupied |
|---|---|
| Hoary cress | 54.28 |
| Phragmites | 16.41 |
| Teasel | 6.96 |
| Perennial pepperweed | 3.78 |
| Tamarisk | 3.74 |
| Dyer's woad | 1.20 |
| Russian olive | 1.19 |
| Field bindweed | 0.19 |
| Dalmatian toadflax | 0.15 |
| Poison hemlock | 0.08 |
| Russian knapweed | 0.01 |
| Scotch thistle | 0.01 |
| Myrtle spurge | 0.01 |
| **Total** | **88.01** |

A large area (30 ac) of hoary cress is present in the very most northern portion of the Farmington Bay MA, and is a mixture of both monotypic and mixed species stands. These areas border Sheeps Road, and are likely influenced by the abundance of roadside weeds and adjoining fallow fields that are heavily infested with noxious weeds. These areas are limited to the northern-most boundary, and it is important to contain them at a minimum, and over time reduce their area by treatment controls and restoration with native grasses. Additional patches of hoary cress and

perennial pepperweed are located along the border with Sheeps Road, and throughout the MA. The Bountiful Landfill is located on the western boundary of the MA, and may be a contributing factor in the presence of large mixed stands of hoary cress in that area. Perennial pepperweed is commonly associated with hoary cress, as well as forming smaller monotypic stands. Goats were introduced to this area in late spring and early summer before the plants set seed.

Perennial pepperweed is found throughout this MA in all habitat types. The spring application of 2,4-D and dicamba may have had some effect on this species, although 2,4-D is not effective and dicamba's effectiveness is greatly increased by disking in the fall and mowing in the spring. For perennial pepperweed monocultures, greater control is achieved if perennial pepperweed infestations are disked in the fall to fragment roots. The plants will resprout but will not have the extensive root system and subsequent resources to draw on the following spring. These newly sprouted plants should then be mowed in the spring between the flowerbud and flowering stage. Again, plants will resprout but with limited ability to rely on root reserves, approximately two to three weeks following mowing depending on soil moisture. Newly resprouted leaves will be larger and parallel to the ground, opposed to the smaller leaves that are perpendicular to the ground on unmowed perennial pepperweed plants. These leaves provide a greater surface area to intercept and absorb herbicide, and more of the herbicide is translocated to the small fragmented rooting structures. Following these treatment methods can provide complete control within one year (TNC 2006). The area should be revegetated immediately with desirable grasses to increase competition with perennial pepperweed, and reduce the risk of other invasive species from establishing in the area.

Phragmites, tamarisk, and Russian olive are located along ditches and water edges, with substantial infestations along the western edge of the MA. Unlike other MAs, Farmington Bay MA had large monotypic stands of teasel. This plant can pose a threat to restoration efforts, and should be addressed in weed management. Approximately 7 ac were mapped, and several monotypic stands identified. Abundant bird and aquatic wildlife use these areas. Goats grazed these areas in the fall of 2006 after the water levels receded reducing above ground biomass requiring the plants to rely on root reserves. Continued treatment of these Class 1 species in these areas in subsequent years will help contain these infestations.

There were small occurrences of Class 2 weed species, including dalmatian toadflax, dyers woad, and Russian knapweed along the border with Sheeps Road and Porters Lane. They were isolated and may be controlled by hand pulling or aggressively treating these small patches before they have an opportunity to spread. The highest success for all three of these species is early spring application of the herbicide 2,4-D. Because of the small stands, a backpack sprayer targeting individual plants may be the most cost-effective and efficient.

## 5.6 WET MEADOW MA

A large area in the center of the Wet Meadow MA was infested with a monotypic stand of hoary cress. Smaller patches radiated out from this, the likely seed source, as well as along the Legacy Parkway ROW. Whereas attention to this large patch is required, the edges of the larger patch as well as the smaller patches need to be aggressively addressed to reduce the spread. Goats grazed this area in the spring of 2006 before seed set, and no herbicide was applied because of the riparian areas.

Perennial pepperweed is found throughout this MA in all habitat types. The spring application of 2,4-D and dicamba may have had some effect on this species, although 2,4-D is not effective and dicamba's effectiveness is greatly increased by disking in the fall and mowing in the spring. For perennial pepperweed monocultures, greater control is achieved if perennial pepperweed infestations are disked in the fall to fragment roots. The plants will resprout but will not have the extensive root system and subsequent resources to draw on the following spring. These newly sprouted plants should then be mowed in the spring between the flowerbud and flowering stage. Again, plants will resprout but with limited ability to rely on root reserves, approximately two to three weeks following mowing depending on soil moisture. Newly resprouted leaves will be larger and parallel to the ground, opposed to the smaller leaves that are perpendicular to the ground on unmowed perennial pepperweed plants. These leaves provide a greater surface area to intercept and absorb herbicide, and more of the herbicide is translocated to the small fragmented rooting structures. Following these treatment methods can provide complete control within one year (TNC 2006). The area should be revegetated immediately with desirable grasses to increase competition with perennial pepperweed, and reduce the risk of other invasive species from establishing in the area.

Phragmites, tamarisk, Russian olive, and teasel were isolated along ephemeral streams and ditches. The goats were introduced into these areas in the fall of 2006 after the water receded reducing biomass and root reserves. Continued efforts are required to contain these Class 1 weed infestations.

Small occurrences of Scotch thistle, musk thistle, Russian knapweed, and dyer's woad were found scattered throughout the MA. Aggressive treatment of these weeds will reduce the ability for them to spread to suitable bird and wildlife habitat found throughout the MA. Addressing these Class 2 and Class 3 infestations with a backpack sprayer or mechanical removal in the spring would help prevent these small infestations from spreading.

**Table 7. Weed Species in the Wet Meadow MA**

| Weed Species | Acres Occupied |
|---|---|
| Hoary cress | 29.20 |
| Teasel | 2.44 |
| Perennial pepperweed | 0.97 |
| Phragmites | 0.83 |
| Tamarisk | 0.39 |
| Quackgrass | 0.24 |
| Russian knapweed | 0.13 |
| Musk thistle | 0.01 |
| Scotch thistle | 0.01 |
| Russian olive | 0.01 |
| Dyer's woad | <0.01 |
| **Total** | **34.23** |

# 6.0 WEED MANAGEMENT TECHNIQUES

## 6.1 BIOLOGICAL CONTROLS

Biological controls are some of the most efficient and cost-effective methods of combating weeds. The definition of "biological control" is the use of live, natural enemies to reduce pest population levels (Coombs et al. 2004). It is important to recognize certain requirements for and limitations of all biological control agents, including public safety, attack of non-target plants, legal access, and measure of success. Many biological control agents have undergone extensive research and development that supports the decision to import or release a natural enemy into a new ecosystem. This section will examine how natural enemies are used. Species-specific natural control agents are further examined in the Noxious Weed Species Accounts section.

### 6.1.1 Goats

The use of goats as a biological control agent has numerous benefits, including reducing chemical use, minimizing soil disturbance, building up soil nutrients, and providing an accessible and unique education opportunity for the public regarding noxious weed management. Goats prefer weeds over grasses for forage. Their narrow, triangular mouths enable them to pick, nibble and chew very fast, and are particularly suited to thorough mastication of most seeds, rendering them non-viable (Lamming 2001). Exposure of seeds to a goat's gastric enzymes completes the breakdown of the structure and toxins of the seeds. In addition, if other seeds of desirable, native species are broadcast during the goats' grazing periods, the small hooves of the goats can gently manipulate the soil without causing extensive damage, and can assist in incorporating the seeds into the surface soil (Lamming 2001).

Goats will eat most poisonous plants that sheep and cattle are unable to tolerate. They have an array of enzymes in their gut and saliva that detoxifies specific compounds (Lamming 2001), though there are some weed species, such as hoary cress, that goats are unable to digest without iodine supplements (McInnis et al. 1993). Grazing selectivity by goats may include the palatability of the weed species, which is often related to age of the plant, as well as goat age and gender. Older male goats prefer musk thistle, Russian thistle, elm trees (*Ulmus* sp.), and Russian olive, whereas the younger goats' first choice is often field bindweed, followed by lupine (*Lupinus* sp.). All goats appear to prefer leafy spurge above all else and will even dig it out from under snowdrifts (Lamming 2001).

Timing is critical to effectively treat weedy species using goats. Flower heads are normally the first to go when goats are released into a weedy field; this includes young knapweeds and yellow star thistle. Leaves are removed from the stems next, leaving the plant with reduced photosynthetic tissue with which to regenerate (Lamming 2001). This grazing method differs from that of ungulates and sheep, where stalks are completely removed and the plants are stimulated to send up new shoots. Many plants rely on root reserves to regenerate after being grazed, thereby depleting their stored carbohydrates. It is in this vulnerable state that goats would be reintroduced to again reduce photosynthetic tissue.

Repeated application of any control mechanism is necessary to gain control of an invasive plant issue, and grazing (i.e., suppression) is no different. It must be repeated within a season and for several consecutive seasons to achieve control. Goats may be a good potential substitute for chemical control, particularly in sensitive areas such as wetlands and along riverbanks.

However, there are several factors to consider in identifying priority areas, timing, and areas with special management issues and applying grazing goats to target areas. First, as noxious plants mature, they become more difficult for goats to digest, and the grazing rate slows down. On the other hand, continual suppression of all the noxious weed priority areas by goats during the *early* management years—so as to prevent weeds from maturing—may be logistically challenging. Therefore, integrating additional control mechanisms including chemical applications in upland areas at least until the problem areas are reduced to maintenance areas are recommended.

### 6.1.2 Plant Pathogens and Insects

The use of herbivores and pathogens found in a given weed's native range can be an effective way to control that noxious weed. Pathogens that cause disease in specific plants have been identified in every category, including bacteria, fungi, nematodes, protozoa, and viruses. Generally, fungi, bacteria, and viruses are the most commonly studied plant pathogens and are therefore the best understood. Some organisms are host-specific, while others are capable of infecting several species. Bacteria require a wound or other opening (stomata) to get into the plant, and are spread passively by rain, moving water, or vectors such as insects. Most fungi are capable of making their own way into susceptible plants, and their spores can be blown long distances or moved in rain or running water. Viruses need a living host and require insects, nematodes, or a wound in the plant for transfer (Coombs et al. 2004).

In order for plant pathogens to be successful, three factors must be met: the pathogen present, a susceptible host, and favorable environmental conditions. Infections or disease can severely damage a plant, but the pathogen will not be effective if, for example, rain washes it from the target weed's leaves. Many plant pathogens produce plant toxins or enzymes that cause cells to leak nutrients that can then be used by the invading organism, and viruses use the plant's DNA to make more of the pathogen. Some plant pathogens interact with other organisms, and the use of known natural insect herbivores as vectors are being explored, including the flea beetle, and the soil-borne fungi Rhizocatonia and Fusarium (Coombs et al. 2004). A mixture of pathogens may often increase the damage incurred by the weed species.

Insects have been successfully used as biological control agent throughout the U.S. They can attack the plant in both the larval and adult stages, causing damage to leaves, stems, flowers, and root systems. Releasing new insects involves the use of either a field insectary or field nursery site. These sites are weed-infested locations with conditions that optimize survival, reproduction, and growth of the insects. New agents are released at insectary sites and left relatively undisturbed. As populations increase over three to five years, surplus agents are harvested for redistribution throughout weed-infested regions. Many factors influence the survival and success of released agents on noxious weeds, and one of the most important factors is how many agents are released and how often they are released. Larger releases are more successful, as they reduce

the risks of genetic effects and accommodate population shifts in highly variable environments. Therefore, it is important to create favorable release conditions that may involve releasing 500 insects at one location, or 250 at two locations, or 100 at five locations.

Federal regulatory parameters are set in place to ensure the natural enemy of the weed would not itself become a threat to the ecosystem. The international Technical Advisory Group (TAG) for the biological control agents of weeds was established in 1987 with input from the U.S. Department of Agriculture (USDA) and U.S. Department of Interior (USDI). This organization provides recommendations to the USDA Animal and Plant Health Inspection Service, Plant Protection and Quarantine (APHIS-PPG). Currently TAG is composed of 15 governmental agencies representing the United, States, Canada, and Mexico.

The TAG reviews two types of documents: noxious weed listing petitions and petitions to release a biological agent. Numerous pathogens and insects have been tested and approved by APHIS-PPQ for release against noxious weed species, and require permits for the importation, transit, domestic movement, and environmental release of the organisms that impact plants (APHIS 2006). Requirements for permits are often species-specific and can change frequently.

## 6.2 CHEMICAL CONTROLS

Numerous herbicides may prove useful to the reduction and eradication of noxious weeds. Because portions of LNP property consist of wetlands and streams, it is necessary to assess the persistence of the chemicals in these environments and their effects on non-target plants and animals. Conversely, chemicals may reside in upland and drier areas due to the lack of water, and subsequent hydrolysis (breakdown) of the herbicide. Herbicides can be categorized according to how they move through a plant: downwardly mobile, upwardly mobile, and contact. Choosing the correct herbicide for the target species is important to avoid damaging desirable species, ensuring effective control of the weed species, and avoiding impacts to wildlife and the environment. Table 8 summarizes commonly used herbicides and their effectiveness on target species. Ratings were presented when available, and were obtained largely from Dewey et al. (2006) and Colorado State University (2000), Environmental Protection Agency Fact Sheets (2006), and specific herbicide labels.

**Table 8. Herbicide Controls for Noxious and Invasive Weed Species**

| Common Name (*Scientific Name*) | 2,4-D | Dicamba | Picloram | Clopyralid | Glyphosate | Imazapic | Imazapyr | Fluazifop | Chlorsulfuron | Metsulfuron | MCPA |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Russian knapweed (*Acroptilon repens*) | P | G,F | E,G | G | G,P | G | | | F | F | |
| Jointed Goatgrass (*Aegilops cylindrica*) | P | P | P | | E,G | | | G | | | |
| Cheatgrass (*Bromus tectorum*) | P | P | P | | E,G | E | | | | | |
| Hoary cress (*Cardaria draba*) | F | G | P | | G,F | G | | | E | E | F |
| Musk thistle (*Carduus nutans*) | E,F | G,F | E | G | E | G | | | G | E | F |
| Yellow star-thistle (*Centaurea solstitialis*) | G | G | | G | | | | | | | |
| Diffuse knapweed (*Centaurea diffusa*) | E,F | E,F | E | G | X | | | | | P | |
| Spotted knapweed (*Centaurea stoebe* ssp. *micranthos*) | F | E,F | E | G | E | | | | | P | |
| Squarrose knapweed (*Centaurea virgata*) | F | F | E | G | X | | | | | P | |
| Canada thistle (*Cirsium arvense*) | F | E,F | E | E | G | | | | G | | |
| Bull thistle (*Cirsium vulgare*) | E | E,F | E | E | E,G | | | | G | | |
| Poison hemlock (*Conium maculatum*) | G | E | E | | E,G | | G | | | | |
| Field bindweed (*Convolvulus arvensis*) | G,F | G,F | G | | G,F | | | | | F | |
| Houndstongue (*Cynoglossum officinale*) | F | G | E | | X | X | | | | | |
| Bermudagrass (*Cynodon dactylon*) | P | P | P | | G | | | | | | |
| Common teasel (*Dipsacus fullonum*) | | G | | | | | | | | G | |
| Russian olive (*Elaeagnus angustifolia*) | G | | | | | | G | | | | |
| Quackgrass (*Elymus repens*) | P | P | P | | G | | | G | | | |
| Leafy spurge (*Euphorbia esula*) | F,P | F | G | | G,F | G | | | | P | |
| Myrtle spurge (*Euphorbia myrsinites*) | G | G | F | | G | | | | | | |
| Dyers woad (*Isatis tinctoria*) | G | E,F | G | | G | G | | | G | E | |
| Perennial pepperweed (*Lepidium latifolium*) | F | G | F | | G | G | G | | E | E | |

**Table 8. Herbicide Controls for Noxious and Invasive Weed Species**

| Common Name (*Scientific Name*) | 2,4-D | Dicamba | Picloram | Clopyralid | Glyphosate | Imazapic | Imazapyr | Fluazifop | Chlorsulfuron | Metsulfuron | MCPA |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Dalmation Toadflax (*Linaria dalmatica*) | F,P | G,P | G | | G | G | | | G | F | |
| Purple loosestrife (*Lythrum salicaria*) | G | | | | G | | | | | G | |
| Scotch thistle (*Onopordum acanthium*) | F | F | E | G | | G | | | G | E | F |
| Phragmites (*Phragmites australis*) | | | | | G | | G | | | | |
| Buffalobur (*Solanum rostratum*) | X | | | | | | | | | | |
| Johnsongrass (*Sorghum halepense*) | P | P | P | | E,G | | | G | | | |
| Tamarisk (*Tamarix ramosissima*) | | | | | X | | | | | | |
| Medusahead (*Taeniatherum caput-medusae*) | P | P | P | | G | | | G | | | |
| Puncturevine (*Tribulus terrestris*) | G | | F | | | G | | | G | | |

E=Excellent, G=Good, F=Fair, P=Poor, X=Unrated
CSU 2000, Laufenberg et al. 2005, TNC 2006

## 6.2.1 Downwardly Mobile

These herbicides are designed to move from the source of sugar production (leaves) to the actively growing parts of the plant (points of energy use). These herbicides interfere or completely eliminate plant growth. Downwardly mobile herbicides can be divided into four different chemistry groups: auxin growth regulators, amino acid inhibitors (aromatic), amino acid inhibitors (branched-chain), and grass meristem destroyers.

### 6.2.1.1 AUXIN GROWTH REGULATORS

Auxin growth regulators are used for control of annual and perennial broadleaf plants in grass crops and non-crop situations. Bending and twisting of leaves and stems are evident almost immediately after application. Delayed symptoms include misshapen leaves, stems, flowers, and abnormal roots. These herbicides are highly non-specific, and injury to non-target plants can be a problem. Examples of these herbicides include 2,4-D, dicamba, picloram, and clopyralid. Their effectiveness on target species is listed below (Dewey et al. 2006, CSU 2000, EPA2006).

#### *6.2.1.1.1 2,4-D*

Trade names include Aqua-Kleen®, Barrage®, and Weedone®. 2,4-D mixed other with herbicides include Crossbow® (2,4-D and triclopyr), Curtail® (2,4-D and clopyralid), Pathway® (2,4-D and picloram), and Weedmaster® (2,4-D and dicamba).

2,4-D is one of the oldest herbicides used in the U.S. It was first developed during World War II and became famous as a component of the controversial Agent Orange used during the Vietnam War. Today, 2,4-D continues to be one of the most commonly used herbicides on the market. Because there is no longer a patent governing the manufacture and sale of 2,4-D, any company is free to produce it. Thus, a variety of inexpensive 2,4-D products are available from different manufacturers. 2,4-D is a selective herbicide that kills dicots (but not grasses) by mimicking the growth hormone auxin, which causes uncontrolled growth and eventually death in susceptible plants (EPA 2006).

The half-life of 2,4-D in the environment is relatively short—an average of 10 days in soils and less than 10 days in water—but its half-life can be significantly longer in cold, dry soils, or where the appropriate microbial community is not present to facilitate degradation (EPA 2006). In the environment, most formulations are degraded to the anionic form, which is water-soluble and has the potential to be highly mobile. Ester formulations are toxic to fish and aquatic invertebrates, but salt formulations are registered for use against aquatic weeds (EPA 2006). 2,4-D is of relatively low toxicity to animals, but some formulations can cause severe eye damage. Certain crops, such as grapes, are highly sensitive to 2,4-D and application of this herbicide should be avoided if they are nearby (EPA 2006). Most formulations are highly volatile and should not be applied when conditions are windy or when temperatures are high.

This herbicide does not control all weeds. It can be effective against perennial pepperweed if used following tilling or disking in the fall and mowing in the spring, but does not provide

adequate control when applied with mechanical treatments (TNC 2006). The combination of 2,4-D and clopyralid has been shown to be effective against Russian knapweed. The highest level of control is achieved when this combination is applied at the flowering stage and less effective at the rosette or bud/bloom stage. However higher rates of application did offer better control when applied at the rosette and bud/bloom stage, but were similar to lower rates when applied at the flowering stage (Laufenberg et al. 2005). Rates of application should be determined according to label instructions.

#### *6.2.1.1.2 DICAMBA*

Trade Names include Post®, Weedmaster® (mix of dicamba and 2,4-D), Banvel®, Clarity®, and Distinct®.

Dicamba readily penetrates leaves, stems, and roots, although not as rapidly as 2,4-D. Because of the different metabolisms of plants, this herbicide, like 2,4-D, is selective for general broad leaf plants, but does not target grass species. Dicamba mimics idole acetic acid (IAA), an auxin hormone that is present in low concentrations in the meristem. IAA is involved in regulating cell growth and differentiation, and dicamba causes the plant to “grow itself to death”. Plants sprayed with dicamba will show signs of downward twisting and curvature of stems, stem swelling and elongation, cracks and splits in bark, leaf curling, and chlorosis at growing points, followed by wilting and necrosis. Initial symptoms are observed within hours after spraying, but it may take several weeks before death occurs (EPA 2006).

Dicamba is moderately persistent in the soil, with a half-life of two to four weeks. The major degradation pathway is metabolism by soil organisms, and occurs more quickly at increased temperature and moisture, and lower pH. It does not adsorb to soil particles and is highly soluble in water, and is therefore highly mobile in soil solution. Microbial degradation is the primary means of dicamba breakdown in aquatic environments, although photolysis may also occur (EPA 2006).

Toxicity to wildlife is minimal. However, dicamba is corrosive and can cause damage to the eyes. Personal protective equipment should be worn as outlined by the herbicide label.

### *6.1.1.3 PICLORAM*

Trade Names include Grazon®, Tordon®, Access®, and Pathway®.

Picloram kills or damages annual and perennial broadleaf herbs and woody plants. It acts as an "auxin mimic" or synthetic growth hormone that causes uncontrolled and disorganized growth in susceptible plants. Picloram does not bind strongly with soil particles and is not degraded rapidly in the environment, allowing it to be highly mobile and persistent (the half-life of picloram in soils can range from one month to several years). In soils, picloram degrades primarily by microbial metabolism, but it can be degraded by sunlight when directly exposed in water or on the surface of plants or soil. Picloram can move off-site through surface runoff and has been found in the groundwater of 11 states (EPA 2006). Picloram may also "leak" out of the roots of treated plants and be taken up by nearby, desirable species (EPA 2006). Some formulations are

highly toxic if inhaled, while other formulations can cause severe eye damage if splashed into the eyes. Because of the persistence of picloram in the environment, chronic exposure to wildlife is a concern, and studies have found weight loss and liver damage in mammals following long term exposure to high concentrations (EPA 2006). Concentrations in runoff reported by researchers are often adequate to prevent the growth of non-target terrestrial and aquatic plants; therefore, picloram should not be applied near waters used for irrigation.

#### 6.2.1.2 AMINO ACID INHIBITORS (AROMATIC)

Amino acid inhibitors are used to control annual grasses, cool-season grasses, and certain broadleaf plants. Glyphosate is the main compound in this class of herbicides. These herbicides are effective only when applied to foliage, as they are rapidly deactivated in the soil, and are relatively non-selective (EPA 2006). The effectiveness of glyphosate on target species is listed below (Dewey et al. 2006, CSU 2000, EPA2006).

##### *6.1.1.2.1 GLYPHOSATE*

Trade Names include RoundUp®, RoundUp-Pro®, Rodeo®, GlyPro®, Accord®, Glyphomax®, Touchdown®.

Glyphosate is a non-selective, systemic herbicide that can control most annual and perennial plants (TNC 2006). It controls weeds by inhibiting the synthesis of aromatic amino acids necessary for protein formation in susceptible plants, by inhibiting the activity of the enzyme 5-enolpyruvylshikimic acid-3-phosphate synthase (EPSP), which is necessary for the formation of the aromatic amino acids tyrosine, tryptophan, and phenylalanine. These amino acids are important in the synthesis of proteins that link primary and secondary metabolism. EPSPs are present in the chloroplast of most plant species, but are not present in animals. Glyphosate is strongly adsorbed to soil particles, which prevents it from excessive leaching or from being taken-up from the soil by non-target plants. It is degraded primarily by microbial metabolism, but strong adsorption to soil can inhibit microbial metabolism and slow degradation. Photo and chemical degradation are not significant in the dissipation of glyphosate from soils. The half-life of glyphosate ranges from several weeks to years, but averages two months. In water, glyphosate is rapidly dissipated through adsorption to suspended and bottom sediments and has a half-life of 12 days to 10 weeks. Glyphosate by itself is of relatively low toxicity to birds, mammals, and fish, and at least one formulation sold as Rodeo® is registered for aquatic use. Some surfactants that are included in some formulations of glyphosate, however, are highly toxic to aquatic organisms, and these formulations are not registered for aquatic use. In terrestrial systems, glyphosate can be applied to foliage, green stems, and cut-stems (cut-stumps), but cannot penetrate woody bark (EPA 2006).

#### 6.1.1.3 AMINO ACID INHIBITORS (BRANCHED-CHAIN)

This type of amino acid inhibitor includes several different chemistry groups. These herbicides stunt root growth, which in time starves the plant. Complete symptom development is very slow and may take over three weeks. These herbicides are used pre- and post-emergence on broadleaf weeds and annual grasses, in crop and non-crop situations (EPA 2006). The effectiveness of

imazapic and imazapyr on target species is listed below (Dewey et al. 2006, CSU 2000, EPA2006).

#### *6.1.1.3.1 IMAZAPIC*

Trade names include Plateau®, Cadre®, Plateau Eco-Paks®.

This herbicide is selective for both the pre- and post-emergent control of some annual and perennial grasses and some broadleaf weeds (TNC 2006). Imazapic kills plants by inhibiting the production of the enzyme acetohydroxy acid synthase (ALS) that catalyzes the production of the three-branched chain amino acids (valine, leucine, and isoleucine) necessary for protein synthesis and cell growth. Only plants have ALS and produce these three amino acids, therefore imazapic is of low toxicity to birds and mammals (TNC 2006). Animals do require these three amino acids, but obtain them by eating plants or other animals. It is moderately toxic to fish, but rapidly photo-degrades in aqueous solutions (EPA 2006). The rate of plant death is usually slow (several weeks), and is likely related to the amount of stored amino acids available to the plant. Imazapic is readily absorbed through leaves, stems, and roots, and is then translocated rapidly throughout the plant accumulating in the meristematic regions, including the root system of perennial plants. It has difficulty crossing the Casparian strip in roots, and does not leak out of the treated plant (EPA 2006). The treated plants stop growing soon after treatment, and chlorosis appears in the newest leaves followed by tissue death that spreads from these points. It has an average half-life of 120 days in the soil, and is degraded primarily by soil microbial metabolism. Degradation by sunlight is minimal on dry soil, but is one to two days in aqueous solutions in, although imazapic is not registered for use in aquatic systems (EPA 2006, TNC 2006).

Imazapic has been useful for weed control in natural area, particularly in conjunction with the establishment of native warm-season prairie-grasses and certain legumes. In some instances, non-native weeds are more susceptible than the desirable native species to imazapic. Imazapic selectively kills plants depending on the species and the rate of application. Conventional application methods (sprayers, controlled drop, injectors, wipe-on devices) are recommended. Post-emergent imazapic applications require the use of spray surfactants such as methylated seed oil or vegetable oil concentrate. Nonionic and silicone-based surfactants may also be used, but are generally less effective. Imazapic may be mixed with other herbicides such as triclopyr, glyphosate, picloram, imazapyr, or other products to provide total vegetation control. Mixtures with 2,4-D and other phenoxy-type herbicides provided less control of perennial grass weeds than imazapic alone(EPA 2006, TNC 2006).

#### *6.1.1.3.2 IMAZAPYR*

Trade Names: Arsenal®, Habitat®, Chopper®, and Stalker®

Imazapyr is a non-selective herbicide used for the control of a broad range of weeds including terrestrial annual and perennial grasses and broadleaved herbs, woody species, and riparian and emergent aquatic species. It can be used where total vegetation control is desired, or in spot applications. Similar to imazapyc, it controls plant growth by preventing the synthesis of branched-chain amino acids (valine, leucine, and isoleucine). The rate of plant death usually is

slow (several weeks) and is likely related to the amount of stored amino acids available to the plant. Only plants have ALS and produce these three amino acids, and therefore, imazapyr is of low toxicity to animals (including fish and insects). Animals need these three branched chain aliphatic amino acids, but obtain them by eating plants or other animals. Imazapyr is not highly toxic to birds and mammals, but some formulations (for instance, the inert ingredients in Chopper® and Stalker®) can cause severe, irreversible eye damage. Studies indicate imazapyr is excreted by mammalian systems rapidly with no bioaccumulation. It has a low toxicity to fish, and algae and submersed vegetation are not affected (EPA 2006).

Because imazapyr is a weak acid herbicide, environmental pH will determine its chemical structure, which in turn determines its environmental persistence and mobility. Below pH 5 the adsorption capacity of imazapyr increases and limits its movement in soil. Above pH 5, greater concentrations of imazapyr become negatively charged, fail to bind tightly with soils, and remain available (for plant uptake and/or microbial breakdown) (EPA 2006).

In soils, imazapyr is degraded primarily by microbial metabolism, not by photolysis or other chemical reactions. The half-life of imazapyr in soil ranges from one to five months. In aqueous solutions, imazapyr may undergo photodegradation with a half-life of two days (EPA 2006).

#### 6.1.1.4 GRASS MERISTEM DESTROYERS

Grass meristem destroyers are used for the selective removal of most grass species from any non-grass crop. There is also some selectivity between grass species. These herbicides cause the discoloration and the disintegration of meristematic tissue at and above the nodes of plants. Leaves yellow, redden, and sometimes wilt. Grass meristem destroyers should be used early post-emergence on annual grasses and post-emergence but before the bolt stage on established perennial grasses (EPA 2006).

##### *6.1.1.4.1 FLUAZIFOP*

Trade Names: Fusilade®, Horizon 2000®, Ornamec®, Fusion®, Tornado®

Fluazifop kills annual and perennial grasses, but does little or no harm to broad-leaved plants. It kills by inhibiting lipid synthesis, particularly at the sites of active growth. In the environment, fluazifop is degraded primarily through microbial metabolism and hydrolysis. It is not degraded readily by sunlight, and the half-life of fluazifop in soils is one to two weeks (EPA 2006). Because it binds strongly with soils, fluazifop it is not highly mobile and is not likely to contaminate ground water or surface water through runoff. In water, fluazifop is rapidly hydrolyzed to fluazifop acid, which is stable in water. Fluazifop is of relatively low toxicity to birds and mammals, but can be highly toxic to fish and aquatic invertebrates (EPA 2006, TNC 2006). The effectiveness of fluazifop on target species is listed below (Dewey et al. 2006, CSU 2000, EPA2006).

##### *6.1.1.4.2 SETHOXYDIM*

Trade Names: Poast®, Torpedo®, Ultima®, Vantage®, Conclude®, and Rezult®

Sethoxydim kills grasses by preventing the synthesis of lipids, but it has little or no impact on broadleaf herbs or woody plants. Sethoxydim is readily degraded through microbial metabolism and photolysis, and possibly by hydrolysis. Numerous degradation products have been identified, some of which are also toxic to plants. The average half-life of sethoxydim in soils is four to five days, but half-lives can range from a few hours to 25 days. Because sethoxydim is water-soluble and does not bind strongly with soils, it can be highly mobile. No reports, however, were found referring to water contamination or off-site movement by sethoxydim (EPA 2006). Sethoxydim is of low toxicity to birds, mammals, and aquatic animals, and has little impact on soil microbe populations (EPA 2006). An oil adjuvant or non-ionic surfactant should be used to facilitate absorption of sethoxydim by plants.

### 6.2.2 Upwardly Mobile

These herbicides move upward through the transpiration stream of the plant and act as photosynthetic inhibitors. Symptoms develop from the bottom to the top on plant shoots. Chlorosis first appears between leaf veins and along the margins that is later followed by death of the tissue. These herbicides typically have excellent soil activity and are used pre and post-emergence in certain annual and established perennial crops. They are also used in non-crop areas for general vegetation control (EPA 2006, TNC 2006).

#### *6.2.2.1 ATRAZINE*

Atrazine may be applied both before and after planting to control broadleaf and grassy weeds. It binds to a protein in photosystem II inhibiting electron transport thereby limiting the photosynthetic capacity of the plant. The EPA is in the process of evaluating data relating to potential effects of atrazine on amphibians from researchers representing eight universities. They found, in consultation with an independent scientific advisory panel, that it is not likely to be carcinogenic to humans. However, there is concern that atrazine has been associated with causing imbalances in hormone levels in laboratory animals, possibly disrupting reproductive and developmental processes. Long-term annual applications of atrazine for weed control in corn apparently result in the persistence of some of its degradation products in the soil 1 yr after the final herbicide application (EPA 2006). Because of the environmental concerns regarding toxicity to wildlife, Atrazine may not be the most desirable herbicide. Atrazine has been effective against cheatgrass and quackgrass.

## 6.3 MECHANICAL CONTROLS

### 6.3.1 Disking and Plowing

Mechanical plant control requires selecting the proper equipment that is adapted to the treatment site. Undesirable species that recover by root sprouting must be uprooted or chemically treated, and repeated treatment or a combination of treatments is may be necessary. Annual weeds, particularly cheatgrass, recover quickly following treatment if the seeds remaining in the soil are allowed to germinate warranting ongoing treatment for at least two seasons. Available

equipment includes mechanisms to turn the soil and severe roots, cut or mow existing vegetation, as well as seeding and restoration equipment.

Disks and plows are designed to turn over soil and surface debris, kill existing vegetation, and prepare a seedbed. They are often mounted with a three-point hitch on a tractor or dozer, and can be used on uneven, steep, and rocky terrain. The use of heavy equipment can be effective, but purchasing or renting equipment can be costly. Chains or harrows are generally pulled between two tractors to uproot trees and shrubs, and can be more economical than disking or plowing. Chaining will uproot larger trees and lightly scarify soil surfaces, but the invasive trees, tamarisk and Russian olive, can resprout from root rendering this ineffective for weed management. Furthermore, chaining has little effect on forbs and grasses (Monsen et al. 2004). Weeds effectively controlled by disking or plowing include cheatgrass, bull thistle and musk thistle.

The drawbacks to disking or plowing include the high cost of equipment and labor, inability to access remote locations or steep slopes, root resprouting of rhizomatous plants species, and creating a bare soil environment that may be invaded by other invasive plant species.

### 6.3.2 Mowing

The ecological basis for mowing weeds is directed at the efficiency of invasive plants to take up and assimilate carbon dioxide, and then alter that physiological function. Properly timed mowing can suppress invasive weeds and favor native and desirable plant species. The most effective time to mow is when the invasive weed is actively growing and the desirable species is dormant. This can prevent weed seed production, as well as stress the plant after they have invested large amounts of energy into flowering and photosynthetic tissue, and repeated mowing can deplete root reserves. Effective mowing is a long-term commitment; some weeds are stimulated by mowing thereby increasing stand densities. However, over several years, the root reserves will become depleted and stand densities will decrease. Species that respond well to mowing include: Canada thistle, dalmatian toadflax, leafy spurge, Russian knapweed and hoary cress (Sheley 2002).

Mowing frequency is dependant on several factors. A spring mowing may be sufficient to reduce annual or biennial species, unless summer rains or soil moisture allows the weed species to regenerate, requiring a second or even third mowing. Rhizotomous weeds often require several mowings over a growing season to successfully control growth. Mowing is not likely to be effective alone, but can increase effectiveness of other control efforts, such as herbicide application (Sheley 2002). Other limitations to mowing include inaccessibility to rocky or remote locations, spreading weed seeds, and high cost of equipment and labor.

### 6.3.3 Fire

Prescribed burns can accomplish several objectives in controlling invasive weedy species including, preventing flowering or seed set, destroying seeds, increase herbicide effectiveness, and eliminate aboveground biomass. Additional benefits from burns are more restoration related in they may stimulate germination of some species by removing litter and releasing nutrients. Fire intensity can be controlled to some extent by timing within a season, but other factors such

as temperature, humidity, and wind speed cannot be controlled (Rice 2005). Annual grasses and forbs have mixed responses to fire. The burn must be timed to reach sufficient temperatures to kill seeds in the soil; existing shrubs and perennial grasses increase temperatures killing cheatgrass seeds, but interspaces may not achieve appropriate temperatures (Evans and Young 1987). Burning alone was not effective against leafy spurge, but increased herbicide effectiveness (Rice 2005), whereas burning had no effect on the herbicide treatment for spotted knapweed (Carpenter 1986). Canada thistle had mixed results increasing dramatically after a spring burn in Manitoba, and decreasing slightly in other studies (Rice 1986). Fire did not affect density or cover of dalmatian toadflax, but seed production and plant biomass increased after one year (Jacobs and Sheley 2003). Tamarisk can resprout after a burn, but herbicide effectiveness can be improved following a tamarisk burn (Rice 2005).

Additional problems with prescribed burning include smoke management problems, especially near urban areas, availability of trained crew members, possibility of burns getting out of control, and massive germination of annual weedy grasses following a cool burn.

### 6.3.4 Removal

Removing plants by hand pulling them to uproot the plant works well for small infestations of annual and biennial plants. Be sure the plant species do not resprout from residual roots.

Pulling does not generally remove the entire root system, and is ineffective for killing rhizomatous weed species, such as Canada thistle, field bindweed, Russian knapweed, leafy spurge, but will reduce seed production. Species that are good candidates for hand pulling include dalmatian toadflax, jointed goatgrass, musk thistle, puncture vine, Scotch thistle, bull thistle, Dyer's woad, and myrtle spurge.

The drawbacks to hand pulling include labor costs, and ability to obtain workers or volunteers to perform the work. Because this is often labor intensive, plan pulling when the soil is moist after a heavy soaking rain (CSU 2000). Some plants produce chemicals that cause allergic reaction or dermatitis in some people. Always wear personal protection equipment (long sleeves, gloves), and avoid areas where chemical treatments or other safety restrictions apply. Moreover, pulling may result in soil disturbance that then stimulates germination of weed seeds present in the soil (CSU 2000).

## 6.4 RESTORATION

Ecosystem restoration requires containing or reducing weedy plant populations in an area while increasing the number and type of native plant species. Restoring native plant communities should include increases in native biological diversity; improved control of water flows resulting in increased sediments and nutrients; and detoxification of polluted areas. Given the high cost of weed control, the benefits of restoration could provide a powerful incentive for restoring native plant communities.

Patterns of community invasibility suggest that both diverse plant communities and late-successional plant communities may be relatively resistant to invasion. Diverse plant communities may use resources more completely, leaving fewer resources available for potential invaders (Tilman 1997). Late-successional plant communities may contain more competitive species and lower levels of available resources than do early-successional plant communities (Vitousek 1997). Native plant species would be expected to compete well under local climatic and edaphic conditions. Therefore, diverse, late-successional native plant communities may exclude many common weed species.

### 6.4.1 Existing Soil and Vegetation Characterization

Prior to revegetation, the soils and existing plant communities from representative reclamation sites should be evaluated. The existing vegetation should be described at each site, and a soil sample should be collected and sent to a soils lab for chemical and physical analyses.

### 6.4.2 Wildlife Considerations

Because vegetation characteristics are a primary determinant of wildlife habitat quality, an important consideration in revegetating weedy areas on LNP property is choosing the species, planting location and distribution of plants. For example, deer and elk should be encouraged to browse away from roads to reduce the number of vehicle-wildlife collisions. Areas within 20 feet of roads should be revegetated with low-growing native plant species that provide little forage or cover will discourage wildlife from using these areas. These areas should only be seeded with Seed Mix #1. On portions of the slopes that are more than 20 feet away from roads, we recommend seeding with both Seed Mix #1 and #2 and planting bare-root and container stock of the following species: rubber rabbitbrush and big sagebrush.

In crucial wildlife habitat corridors, native shrubs should be planted where needed in the corridor. Planting antelope bitterbrush, a highly palatable species, in the center of the wildlife corridor may encourage animals to stay within the corridor as they cross through the property. In so doing, wildlife road crossings will be more predictable and, thus, easier to manage.

### 6.4.3 Fire Considerations

Shrubs should not be planted adjacent to roads or structures. In addition, native firewise grass and forb restoration species are available for planting in these areas.

## 6.4.4. Revegetation Shrub Species

### *6.4.4.1 Big sagebrush (Artemisia tridentata ssp. wyomingensis)*

Sagebrush individuals are generally 1.5 to 3 feet tall at maturity. This species is not shade tolerant, therefore it grows best on south to west aspects and flat areas. Sagebrush is most common on foothills, undulating terraces, slopes, and plateaus, but also occurs in basins and valley bottoms (Cronquist et al. 1994). Sagebrush grows at elevations from 2,500 to 7,000 feet above sea level and requires 10-18 inches of precipitation annually (Hironaka et al. 1983, Winward and Tisdale 1977). This species is not particularly palatable to wildlife; deer will eat this sub-species of big sagebrush if nothing else is available (McArthur et al. 1978). Following disturbance, this species colonizes areas through seed dispersal. Sagebrush have mycorrhizae on roots, which allow them to succeed in nutrient poor soils. This species is easily established through broadcast seeding and bare root shrub planting (USDA 2004). This species is not inhibited by the growth of other shrub, forb or grass species in its proximity.

### *6.4.4.2 Rubber rabbitbrush (Ericameria nauseosa ssp. albicaulis)*

This deciduous shrub species grows from 12 to 90 inches in height (McArthur 1977). This subspecies of rubber rabbitbrush favors sunny, open sites foothills and open slopes from 3,000 to 8,000 feet (900-2,400 m) (Institute for Land Rehabilitation 1979). Rubber rabbitbrush is excellent for soil stabilization and erosion control (Davis et al. 1985). It is also well suited for use on degraded winter ranges (Rosentreter and Jorgensen 1986). Rubber rabbitbrush has a deep root system and can establish rapidly, even on severe sites. Plants produce large quantities of leaf litter, which produces soil mulch. Seedlings are easy to establish, even on unprepared seedbeds (Monsen and Stevens 1987). Drill seeding, direct seeding, and aerial application have all been used effectively (McArthur 1977). Because it is deciduous, this species is not good winter forage for big game. Rubber rabbitbrush grows on a wide range of soil. In general, preferred soils tend to be medium to coarse-textured and somewhat basic (Institute for Land Rehabilitation 1979). Rubber rabbitbrush is a fire-adapted species that is typically unharmed or enhanced by fire (Young 1983). Recovery time is often rapid to very rapid. Rubber rabbitbrush is generally regarded as an early seral species that rapidly invades and colonizes disturbed sites (Hegerhorst et al. 1987).

## 6.4.5 Revegetation Grasses

The following grass species have been chosen for their success on non-productive soils, their drought tolerance, their longevity and their slope-stabilizing root growth.

- Bluebunch wheatgrass (*Pseudoroegneria spicata* ssp. *spicata*), Canby bluegrass (*Poa canbyi*), sheep fescue (*Festuca ovina*), western wheatgrass (*Pascopyrum smithii*) and Indian ricegrass (*Achnatherum hymenoides*)

The following grass species have been chosen for their fast growth rates and success as erosion control species:

- Slender wheatgrass (*Elymus trachycaulus* ssp. *trachycaulus*), bottlebrush squirreltail (*Elymus elymoides*) and QuickGuard sterile triticale (a sterile cross between wheat and rye)

### 6.4.6 Revegetation Forbs

The following forb species have been chosen for their success on non-productive soils, their drought tolerance, their longevity and their beauty.

- Palmer penstemon (*Penstemon palmeri*), Rocky Mountain penstemon (*Penstemon strictus*), California poppy (*Eschscholzia californica*), Munro globemallow (*Sphaeralcea munroana*) and blue flax (*Linum lewisii*)

The following forb species have been chosen for their drought tolerance and nitrogen-fixing ability.

- Silky lupine (*Lupinus sericeus*) and northern sweetvetch (*Hedysarum boreale*)

### 6.4.7 Slope Preparation and Seeding

Where necessary, the first step in slope preparation will be the interception of upslope runoff from snowbank melt, rainfall and irrigation by either berms or dikes. This runoff needs to be channeled away from the reclamation slopes and into native drainages. On slopes dominated by weedy plant species, appropriate weed treatments methods will help reduce the population of undesirable plant species without significantly impacting slope stability. Seeded slopes will be watered by truck immediately following installation of the compost blanket to aid in successful establishment.

On slopes with at least two inches of topsoil but no significant vegetation, the soil surface will be scarified or covered in mesh netting to help the hydromulch adhere to the slope surface. The grass and forb seed mix should be applied as part of the hydromulch. The shrub seed mix should be broadcast separately over the surface of the hydromulch. Successful, extensive native grass and forb establishment is known to take three to five years following the initial seeding. In order to effectively control erosion during this time, QuickGuard sterile triticale grass is included in the seed mix to provide a cover crop during the first year following seeding (Personal Communication, Daryl Bennett, Granite Seed on September 19, 2006). In order to reduce the establishment of undesirable, weedy plant species, liquid fertilizer should not be added to seeded slopes (USDA 2004).

Seeds can the aerial broadcast using fixed-wing aircraft or helicopters, or small areas can be broadcast or hand seeded. Seeds must be cover afterward using a harrow or rake, failure to cover the seed will result in high seed predation and low germination rates. Drill seed is successful on areas accessible with a tractor. It is important that sites are correctly seeded with the appropriate seedmix or the annual grasses will quickly recover and occupy openings (Monsen et al. 2004).

Perennials must be planted in cheatgrass sites, otherwise cheatgrass will remain the dominant grass. If perennial seedlings survive the first growing season, they will usually attain dominance.

After the second or third growing season, the perennials should be fully established, and mature in six years if properly managed.

On sites where grass and forb species are already successfully established, shrub seedlings will be planted as described below.

| Species | Pls Lbs per Ac (Broadcast Rate) |
|---|---|
| Bluebunch wheatgrass (*Pseudoroegneria spicata* ssp. *Spicata)* | 6.4 |
| Slender wheatgrass (*Elymus trachycaulus* ssp. *trachycaulus)* | 3.2 |
| Bottlebrush squirreltail (*Elymus elymoides)* | 1.6 |
| Sheep fescue (*Festuca ovina* var. *black sheep)* | 1.0 |
| Streambank wheatgrass (*Elymus lanceolatus* ssp. *psammophilus)* | 6.4 |
| Great Basin wildrye (*Leymus cinereus)* | 3.0 |
| Needle and thread grass (*Hesperostipa comata* ssp. *comata)* | 3.2 |
| Western wheatgrass (*Pascopyrum smithii)* | 3.2 |
| Indian ricegrass (*Achnatherum hymenoides)* | 3.2 |
| TOTAL | 28.9 |
| QuickGuard Sterile Triticale cover crop (add to mix) | 8.0 |

### 6.4.8 Shrub and Tree Planting Details

In areas where additional shrub cover is desired, 200 shrub seedlings should be planted per acre, resulting in approximately 10 percent shrub cover. A 50 percent mortality rate is to be expected when planting most bare root and containerized shrub seedlings (USDA 2004). In the spring, bareroot shrubs will be kept moist and cool throughout the planting process to avoid root desiccation. At the time of planting, organic amendment (topsoil and/or compost) will be added to the planting holes as well as around the base of each seedling.

On slopes requiring seeding and shrub installation, the shrubs would be planted prior to seeding. This would help maintain the structural integrity of the hydromulch or a compost blanket. The seeds/mulch would be sprayed around the newly planted shrub seedlings.

During the fall and spring plantings, shrubs will be watered by truck immediately following planting to aid in successful establishment. For spring plantings, supplemental water will be necessary to ensure seedling success. One option would be water shrubs weekly (if there is no rain) during the first growing season using a water truck. If this method is chosen, the water truck operator should make every effort to target the shrubs rather than broadcast water over the entire slope side. This will help reduce the establishment of weedy plant species and reduce the potential for erosion. A second option is the installation of Rainbird irrigation supplements at the base of each shrub at the time of planting (see Section 8.3 Irrigation needs). These would provide time-released, targeted water to each of the shrub plantings for 30 to 90 dry days.

Restoration of riparian areas includes not only removing the weedy species, but replacing them with desirable species. This may include cottonwood (*Populus fremontii*) and coyote willow (*Salix exigua*). Both cottonwood and willow respond well to pole planting (NRCS 2006). Pole planting must be conducted on dormant poles in the winter before bud break, January or February is optimal. Branches of nearby trees can be cut, 3 inch (7.5 cm) diameter for Cottonwood and 1 inch (2.5 cm) for willow, for poles. Poles should be removed from several trees to avoid a monoculture of a single species stand and promote genetic diversity. Deep augers may be required to dig holes deep enough for cottonwood poles; they are more successful if they are near the water table. Willow waddles or weaves are effective as soil erosion barriers as well as developing new willow stands. Willow branches, or whips, can be tied together and laid flat against a steep bank to hold the soil in place. Adventitious roots and will develop holding the soil in place, while new shoots will sprout along the branches. Fencing around the area or individual poles for protection from beaver or cattle may be required.

Large areas can be broadcast seeded, but small tracts may require hand seeding. Soil should be moist, but not wet to avoid a poor seedbed. Seeding interspersed with transplants or pole plants is a useful technique to increase diversity and competition against weeds. Large woody transplants or poles can stabilize banks that allow seeds to germinate.

### 6.4.9 Seedling Protection Details

1. Use mulches around the base of each shrub to retain water and protect the shrub roots from drastic changes in air temperature.
2. Provide supplemental water to establish seedlings and maintain them during dry seasons (see Section 8.3 Irrigation Needs**)**.
3. Use erosion control structures on the soil surface to reduce soil and water erosion. This should include the compost blanket and/or a sufficient number of straw waddles to prevent slope erosion.
4. Use planting stock with a good root to shoot ratio to avoid damage associated with extreme soil temperatures. Seedlings with excessive aboveground foliage should be pruned prior to installation to reduce stress on the root system.
5. Use plant species and associations adapted to site conditions.

### 6.4.10 Seasonal Timing of Seeding/Planting Efforts

All seedings should take place in the late fall. Shrub seedlings should be installed in late fall and early spring when soil moisture content is high and the chances of precipitation are greatest (USDA 2004).

# 7.0 MONITORING

While it is often accepted that the invasion of noxious weeds pose a primary threat to the integrity and function of an ecosystem, quantitative or experimental evidence is often lacking. Establishing a strong monitoring program that can be easily followed and repeated will greatly assist in future efforts to make appropriate management decisions. The monitoring plan should include careful documentation of existing weed infestations and control agent release sites, designed to capture changes in plant performance and plant populations. The use of photo and GPS technology to enhance mapping efforts, capture abiotic factors, and monitoring off-season conditions to better understand seasonal changes that may affect the biological control agents can provide insight into the best management techniques to combat noxious and invasive weed population. The development of a long-term monitoring program is further examined for the LNP in the Habitat Management Plan.

## 7.1 Weed Control Monitoring Objectives

Establishing a strong monitoring program that can be easily followed and repeated will greatly assist in future efforts to make appropriate management decisions. The monitoring plan should include careful documentation of existing weed infestations and control agent release sites, designed to capture changes in plant performance and plant populations. The use of photo and GPS technology to enhance mapping efforts, capture abiotic factors, and monitoring off-season conditions to better understand seasonal changes that may affect the biological control agents can provide insight into the best management techniques to combat noxious and invasive weed population.

Monitoring follows mapping and can have a variety of objectives, including:

- Assessing the impact of management activities
- Detecting weeds in uninfested areas
- Assessing the impact of weeds on the ecosystem
- Assessing the effects of management activities on the ecosystem
- Evaluating weed spread

Monitoring provides feedback on the efficacy of management activities. Management plans can and should be adjusted based on feedback from monitoring. Although monitoring is often restricted to small areas or plots, weed expansion or contraction across large geographic areas can be monitored by comparing maps from different years.

## 7.2 Weed Monitoring Protocols

The North American Weed Management Association (NAWMA) system for mapping and monitoring weedy plant species provides a standard that helps land owners to coordinate and synchronize efforts to control and prevent plant invasions. The mapping and monitoring system provides a standardized format for collecting and mapping weedy plant species that allows land owners and managers to share information concerning the status of weedy species on adjacent or

similar properties. It is also a tool for monitoring changes in size, density and species composition of weedy infestations over time. The NAWMA monitoring system details the data collection requirements and methods in two documents available at their website (NAWMA 2003). They recommend ocular estimates of percent cover of each species within a 168$m^2$ circle within each weedy area being assessed. For every fifth polygon assessed, they suggest quantitative percent cover estimates in three 1 $m^2$ quadrats nested in the larger circle. All monitoring sites should be permanently staked, if possible, to ensure subsequent monitoring efforts accurately capture changes in weedy infestations.

## 7.3 Revegetation Monitoring Methods

Revegetation success should be monitored during the first three growing seasons. In addition, revegetated slopes should be visited twice during summer months to obtain visual percent cover estimates by plant species and morphological class. These measurements would provide information about which grass, forb and shrub species are most successful in various biophysical conditions (soil type, slope, aspect, etc). Erosion should be monitored in the early spring during shrub installations and again in the summer during the vegetation evaluations.

## 7.4 Evaluation of Successful Revegetation

The success of slope revegetation efforts should be evaluated during each site visit. A 50 percent mortality rate is to be expected when planting most bare root and containerized shrub seedlings (USDA 2004). This is due, in part, to the palatability of shrub seedlings for foraging wildlife species. The other major factor is transplant shock, which is likely to impact a significant percentage of the shrub seedlings. Therefore, the shrub installation should be considered a success if more than 50 percent of shrub seedlings survived the first three years following installation.

Successful, extensive native grass and forb establishment is known to take three to five years following the initial seeding. In order to effectively control erosion during this time, a sterile rye grass is included in the seed mix to provide a cover crop during the first year following seeding (Personal Communication, Daryl Bennett, Granite Seed on September 19, 2006). Each fall and spring, slopes should be examined for native growth. The seeding should be considered successful if a significant increase in the number and type of native species were to occur each year, with substantial biomass and diversity after three years.

## 7.5 Contingency Measures

Possible conditions that could contribute to failure include: insufficient soil nutrients, lack of erosion control measures, improper shrub installation, lack of water, extreme precipitation events and extreme air temperatures. Of these conditions, the first four are preventable, while the latter two are not. If revegetation is not successful on certain slopes, those slopes should be carefully evaluated to determine the cause of failure. Once the cause is determined, the situation should be remedied (if, and where, possible) and the slope revegetated. Given that 50 percent mortality of

shrub plantings is expected, only slopes exhibiting 60 percent or greater shrub mortality should be replanted.

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# 8.0 IMPLEMENTATION

Developing and carrying out an implementation plan requires determining how best to use the available resources to achieve the desired result. Each project will be unique, and require information obtained from this plan as well as additional data. A checklist and example has been developed to aid in this process.

1. Map project location and size, and identify all noxious and invasive weed species and relative abundance.

   Example: Fifteen feet on either side of dirt road X has 50% cover of cheatgrass and 20% cover dalmatian toadflax for five miles, for a total of 18 acres.

2. What are the best treatment options for these species?

   Example: Cheatgrass in a winter annual that germinates in the fall from seed, dalmation toadflax is a perennial that also reproduces from seed. For chemical control, the herbicides imazapic and glyphosate effectiveness are rated as excellent and good for cheatgrass and dalmatian toadflax respectively. Glyphosate is a non-selective herbicide, and may affect non-target species. Determine which is appropriate for this project.

   There is a biological control for dalmatian toadflax, but it has not shown to be effective at other Utah locations; no biological control exists for cheatgrass. Tilling may be effective against cheatgrass, but is not advised against dalmatian toadflax due to its extensive root system that will resprout. Therefore, chemical controls are the most effective for these target species.

3. When is the best time to implement controls?

   Example: Both cheatgrass and dalmatian toadflax can be sprayed in the fall or early spring. For the most effective treatment, spray in the fall to control newly germinating cheatgrass seedlings. Two to three weeks after herbicide application, the area should be ripped and seeding with native perennial grasses to reduce competition. Heavy mulch of straw or wood fiber will reduce the ability of invasive seeds to germinate and retain moisture for native perennial grasses.

4. Schedule monitoring and mitigation.

   Walk the length of the corridor the following March to look for germinating cheatgrass or dalmatian toadflax. Spot spray any weed individuals avoiding native species.

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# APPENDIX C1. TREATMENT CONTROL METHODS

| Common Name (*Scientific Name*) | Reproduction Characteristics | Control Methods | Application Timing | Application Method | Duration Of Treatment | Treatment Remarks |
|---|---|---|---|---|---|---|
| Russian knapweed (*Acroptilon repens*) | • Annual, biennial, short lived perennial<br>• Spreads primarily by adventitious shoots from widely spreading horizontal roots<br>• Seed remain viable in soil for 2-8 years | • Chemical | • Spring - when plants have recently bolted<br>• Summer - search for missed plants that have just flowered<br>• Fall – when plants are in full bloom | • Excellent: picloram, clopyralid + 2,4-D<br>• Good: dicamba, picloram, glyphosate, imazapic, clopyralid, clopyralid + 2,4-D<br>• Fair: dicamba, metsulfuron, chlorsulfuron<br>• Poor: 2,4-D, glyphosate | • Minimum of 2 years for herbicide applications to deplete seed bank | • Picloram should be applied in the fall immediately following mowing; picloram can persist in the soil for several years<br>• Clopyralid + 2,4-D can be applied any time of year, but is most effective at the flowering stage<br>• Control existing infestations using a combination of methods<br>• Reseed with desirable grasses that are unaffected by broadleaf herbicides<br>• Glyphosate, picloram, and dicamba have shown mixed results, and should be applied carefully according to label instructions regarding application requirements and restrictions |
| | | • Biological | • Spring after bolting to remove flower heads | • Grazing<br>• Competition with perennial grasses<br>• Nematode: *Subanguina picridis* | • Graze several times annually for several years to deplete seed bank<br>• Nematode effectiveness not consistent year to year | • Goats prefer flowering heads, but will graze green tissue<br>• Once plants bolt, there are no more buds capable of reproduction until fall; grazing eliminates seed production, but will not kill plant<br>• Removing aboveground biomass forces them to use root reserves and stresses plant; re-emerged plants are smaller and lower in vigor<br>• Can be outcompeted in moist locations by perennial grasses, reseed with desirable grasses<br>• Nematode needs to be propagated and redistributed on large scale, and is not cost effective with present techniques |
| | | • Mechanical | • Spring after bolting to remove flower heads | • Mow<br>• Hand pulling | • Several times annually for several years<br>• Mowing will prevent flowering and seed set depleting soil seed bank | • Once plants bolt, there are no more buds capable of reproduction until fall<br>• Eliminates seed production, but will not kill plant<br>• Removing aboveground biomass forces them to use root reserves and stresses plant; re-emerged plants are smaller and lower in vigor<br>• Mow in the fall, followed immediately by picloram application to ensure herbicide reaches soil surface<br>• Russian knapweed may contain a carcinogenic compound, use protective equipment when hand pulling |
| Jointed goatgrass (*Aegilops cylindrica*) | • Winter annual | • Chemical | • Spring, apply to actively growing vegetation | • Excellent: glyphosate<br>• Good: glyphosate, fluazifop<br>• Poor: 2,4-D, dicamba, picloram<br>• Unrated: glyphosate, sulfometuron methyl | • Several years | • Many herbicides are broadleaf specific, read label to be sure correct formulation is used for grasses<br>• Grass selective herbicides may kill desirable grasses<br>• Glyphosate has shown mixed results, and should be applied carefully according to label instructions regarding application requirements and restrictions |
| | | • Biological | • Early spring | • Grazing | • Several years | • Cattle and goats may graze when plants are green |
| | | • Mechanical | • Spring, after flowering and before seed set | • Mowing | • Several Years | • Mowing may be required several times during the season |
| Cheatgrass (*Bromus tectorum*) | • Winter annual | • Chemical | • Fall after germination<br>• Spring before flowering | • Excellent: imazapic, glyphosate<br>• Good glyphosate, fluazifop<br>• Poor: 2,4-D, dicamba, picloram<br>• Unrated: sethoxydim, atrazine | • Several years | • Check label for potential harm to desirable grasses<br>• Glyphosate has shown mixed results, and should be applied carefully according to label instructions regarding application requirements and restrictions |
| | | • Biological | • Spring | • Grazing | • Several years | • Grazing can help control cheatgrass if two grazing periods occurs each spring for at least two consecutive years. First, graze just before inflorescences emerge, then graze again before panicles emerge |

| Common Name (*Scientific Name*) | Reproduction Characteristics | Control Methods | Application Timing | Application Method | Duration Of Treatment | Treatment Remarks |
|---|---|---|---|---|---|---|
| | | • Mechanical | • Not recommended | • Not recommended | • Not recommended | • Cutting not recommended as cut plants will produce new stems and seeds at cut height. |
| Hoary cress (*Cardaria draba*) | • Perennial<br>• Germinates in the fall<br>• Spreads primarily from adventitious buds from lateral rhizomes<br>• Seed remain viable in soil for three years | • Chemical | • Apply herbicide during bud or flowering stage (May-June)<br>• Reapply herbicide in the fall if new growth occurs | • Excellent: metsulfuron, chlorsulfuron, imazapic<br>• Good: dicamba, glyphosate, imazapic, 2,4-D, metsulfuron + dicamba + 2,4-D, imazapic + glyphosate<br>• Fair: 2,4-D, glyphosate, MCPA<br>• Poor: picloram | • Multi-year commitment | • Control existing infestations using a combination of methods<br>• Metsulfuron and chlorsulfuron must be applied to actively growing green tissue before flowering<br>• Imazapic applied to regrowth in the fall was very effective<br>• Flowers will immediately set seed following herbicide application, therefore spray at bud stage prior to flowering or foliage in the fall<br>• May require mowing or grazing to synchronize flowering to ensure uniform herbicide application, however mowing may stimulate lateral root growth<br>• Glyphosate, imazapic, and 2,4-D have shown mixed results, and should be applied carefully according to label instructions regarding application requirements and restrictions |
| | | • Biological | • Bud to flowering stage, avoid seeds | • Grazing | • On-going, grazing reduces seed production, but does not kill plants | • Can cause iodine deficiency in goats, must be grazed on mixed species stands or supplemented with iodine<br>• Seeds contain cyanide<br>• Toxic to cattle and horses |
| | | • Mechanical | • Ongoing throughout growing season | • Mowing<br>• Tilling and removal | • Mowing effects not evident for 2-3 years | • Mow repeatedly to exhaust root system<br>• Follow-up mowing is most effective within 10 days of re-emergence<br>• Cut flowers can still mature into viable seed<br>• Uprooted plants will resprout increasing density, therefore tilling must be combined with removing plants and roots |
| Musk thistle (*Carduus nutans*)<br><br>Scotch thistle (*Onopordum acanthium*) | • Musk thistle: Biennial, summer or winter annual<br>• Musk thistle seed remain viable in soil for 10-15 years, and flowers produce up to 1,000 seeds per head<br>• Scotch thistle: Biennial<br>• Scotch thistle seeds often remain dormant in the soil up to 5 years | • Chemical | • Spring: Actively growing rosettes to early bolting<br>• Fall: Actively growing rosettes[1] | • Excellent: 2,4-D, glyphosate, metsulfuron, picloram<br>• Good: dicamba, imazapic, chlorsulfuron, clopyralid, dicamba + 2,4-D,<br>• Fair: 2,4-D, dicamba, MCPA | • Multi-year commitment | • Musk and Scotch thistles can be treated together<br>• Reseed with desirable grasses that are unaffected by broadleaf herbicides<br>• 2,4-D and dicamba have shown mixed results, and should be applied carefully according to label instructions regarding application requirements and restrictions |
| | | • Biological | • Spring, bud to flower | • Grazing<br>• Musk thistle weevil (*Rhinocyllus conicus*)[5] | • Multi-year commitment | • Older male goats prefer musk thistle compared to younger goats<br>• Repeat grazing 4 to 7 weeks to remove new flowers<br>• Weevil adults will feed on leaves, mate, and deposit eggs on bracts |
| | | • Mechanical | • Early bud stage prior to flowering | • Mowing<br>• Removal | • Multi-year commitment | • Mow repeatedly to remove flowers<br>• Bag and burn cut plants, because seeds can still mature after cutting<br>• Repeat 4 to 7 weeks as musk thistle continues flowering all summer |
| Yellow star-thistle (*Centaurea solstitialis*) | • Annual, germinating in the fall<br>• Reproduces entirely by seeds that may remain viable for several years | • Chemical | • Spring: rosette to bolt<br>• Fall: rosette[1] | • Good: dicamba, 2,4-D, clopyralid | • Several years to eliminate seed bank | • Reseed with desirable grasses that will not be affected by broad leaf herbicides |
| | | • Biological | • Rosette to bud | • Grazing<br>• Seedhead weevil[5] | • Multiple grazing periods per year over multiple years to eliminate seed bank | • Cattle, sheep and goats will graze yellow star-thistle before it has spines<br>• Causes chewing disease in horses |
| | | • Mechanical | • Summer, before seed set | • Cutting | • Several years to eliminate seed bank | • Does not eliminate infestation, but will reduce seed production |
| Diffuse knapweed (*Centaurea diffusa*) | • Diffuse knapweed: Annual to short-lived perennial | • Chemical | • Late spring, active growth from rosette to mid bolting stage | • Excellent: 2,4-D, dicamba, picloram, glyphosate | • Minimum of two years | • Seed area with desirable perennial native grasses; grasses will out-compete knapweed |

| Common Name (*Scientific Name*) | Reproduction Characteristics | Control Methods | Application Timing | Application Method | Duration Of Treatment | Treatment Remarks |
|---|---|---|---|---|---|---|
| Spotted knapweed (*Centaurea stoebe* ssp. *micranthos*) | • Spotted knapweed: biennial to short-lived perennial<br>• Both reproduce by seed, spotted can reproduce vegetatively<br>• Spotted knapweed seeds remain viable for 8 years | | | • Good: dicamba, clopyralid<br>• Fair: dicamba, 2,4-D<br>• Poor: metsulfuron | | • Knapweed will reinvade if competitive grasses do not establish<br>• Herbicides are most effective when applied to the rosette stage<br>• 2,4-D and dicamba have shown mixed results, and should be applied carefully according to label instructions regarding application requirements and restrictions<br>• Glyphosate may not be as effective against diffuse knapweed compared to spotted knapweed |
| | | • Biological | • Bud to bloom | • Goats<br>• Fungi[5]<br>• Weevil[5]<br>• Seedhead flies[5]<br>• Root beetle[5]<br>• Moth[5] | • Several years for goats to eliminate soil seed bank<br>• Unknown for insects and pathogens | • Goats won't eat dry seed heads<br>• Livestock grazing twice in the spring can reduce seed set by 50%<br>• Grazed plants may live and rebolt<br>• Biological control agents are available, but several agents may be required to control diffuse and spotted knapweed |
| | | • Mechanical | • Before seed set | • Mowing | • Several years, combine with herbicide treatment | • Cut plants may live and rebolt |
| Squarrose knapweed (*Centaurea virgata*) | • Long lived perennial<br>• Reproduce by seed dispersing with the head as a unit | • Chemical | • Spring, rosette to bolt stage[1] | • Excellent: picloram<br>• Good: clopyralid<br>• Fair: dicamba, 2,4-D<br>• Poor: metsulfuron<br>• Unrated: glyphosate | • Minimum of two years | • Seed area with desirable perennial native grasses; grasses will out-compete knapweed<br>• Knapweed will reinvade if competitive grasses do not establish<br>• Herbicides are most effective when applied to the rosette stage |
| | | • Biological | • Spring | • Grazing | • Several years | • Goats will graze the flower heads and buds preferentially, followed by the green photosynthetic tissue |
| | | • Mechanical | • Spring, bolt to flower | • Mowing | • Several years | • Not recommended for mature plants as it will facilitate seed set |
| Canada thistle (*Cirsium arvense*)<br><br>Bull thistle (*Cirsium vulgare*) | • Canada thistle spreads rapidly through creeping horizontal roots<br>• Seeds are viable in the soil for several years<br>• Bull thistle is a biennial forb | • Chemical | • Spring: rosette to early bloom<br>• Fall: Apply herbicide to new growth (cuticle is too thick on older leaves)[1] | • Excellent: 2,4-D, dicamba, picloram, glyphosate, clopyralid, clopyralid+2,4-D, aminopyralid, picloram<br>• Good: chlorsulfuron, glyphosate<br>• Fair: dicamba, 2,4-D | • Two year minimum | • Monitor annually just before or during bloom period (14-18 hours of daylight)<br>• Spreads primarily by vegetative reproduction<br>• Combine methods of control suggested<br>• 2,4-D, dicamba, and glyphosate have shown mixed results, and should be applied carefully according to label instructions regarding application requirements and restrictions<br>• 2,4-D is more effective against bull thistle than Canada thistle |
| | | • Biological | • Full bud before flower | • Grazing | • Repeat in one-month intervals throughout growing season | • Plants spend energy reproducing photosynthetic tissue reducing root reserves, and will die after two or three grazings |
| | | • Mechanical | • After flowering before seed set | • Mowing<br>• Shading | • Repeat in one-month intervals throughout growing season | • Plants spend energy reproducing photosynthetic tissue reducing root reserves, and will die after two or three mowings<br>• Tilling or digging not recommended, cut roots will resprout<br>• Bull thistle cannot tolerate shade |
| Poison Hemlock (*Conium maculatum*) | • Biennial | • Chemical | • Spring and summer when plants are actively growing[1] | • Excellent: dicamba, picloram, glyphosate<br>• Good: 2,4-D, imazapyr, glyphosate | • Several years | • Poison hemlock is often found in riparian habitats, and aquatic formulations of the herbicides are recommended<br>• Glyphosate has shown mixed results, and should be applied carefully according to label instructions regarding application requirements and restrictions |

| Common Name (*Scientific Name*) | Reproduction Characteristics | Control Methods | Application Timing | Application Method | Duration Of Treatment | Treatment Remarks |
|---|---|---|---|---|---|---|
| | | • Biological | • Summer | • Palearctic moth (*Agonopteris alstoemeriana*)[5] | • Several years | • The palearctic moth feeds exclusively on poison hemlock |
| | | • Mechanical | • Before seed set | • Digging<br>• Pulling<br>• Burning | • Several years | • Offers good control, deplete seed bank |
| Field bindweed (*Convolvulus arvensis*) | • Perennial<br>• Spreads by rhizome and seed<br>• Seeds can be viable for up to 50 years | • Chemical | • Fall, when plants are vigorous and before seed set | • Excellent 2,4-D, dicamba<br>• Good: 2,4-D, dicamba, picloram, glyphosate<br>• Fair: 2,4-D, dicamba, glyphosate, metsulfuron, 2,4-D+dicamba<br>• Poor: 2,4-D+clopyralid[1] | • 2-3 years | • Herbicide can be applied any time as long as tillers are 1 foot (30 cm)<br>• 2,4-D, dicamba, and glyphosate have shown mixed results, and should be applied carefully according to label instructions regarding application requirements and restrictions<br>• The best results are achieved when 2,4-D is mixed with other herbicides: dicamba, glyphosate, or picloram<br>• Drought reduces effectiveness of herbicide, dicamba better than 2,4-D under drought conditions<br>• Some biotypes are resistant to glyphosate |
| | | • Biological | • Summer | • Grazing<br>• Gall mite<br>• Plant competition | • Ongoing | • Can be toxic to cattle and hogs<br>• Goats and sheep will graze field bindweed<br>• Mites may infest native species<br>• Mites susceptible to herbicides<br>• Competition with perennial grasses reduces cover |
| | | • Mechanical | • Not recommended | • Not recommended | • Not recommended | • Tilling not recommended without herbicide treatment, may increase number of seedlings from severed roots<br>• Mowing encourages ground hugging growth |
| Houndstongue (*Cynoglossum officinale*) | • Biennial<br>• Reproduces entirely from seed | • Chemical | • Apply in early spring before blooms occur.<br>• Herbicide application at the rosette stage has been successful[1] | • Excellent: picloram<br>• Good: dicamba<br>• Fair: 2,4-D<br>• Unrated: glyphosate, imazapic | • Multiple years | • Apply according to label requirements and restrictions |
| | | • Biological | • Not available | • Grazing | • Not recommended | • Not recommended, it is toxic to cattle and horses. |
| | | • Mechanical | • Summer, before seed set | • Tilling | • Several years | • Flowering plants should be bagged or burned to prevent seeds from maturing |
| Bermudagrass (*Cynodon dactylon*) | • Mat-forming rhizomatous grass that moves along the ground and forms adventitious roots wherever a node touches the ground<br>• Reproduces through seeds as well as rhizomes; | • Chemical | • Early spring, seedling stage[1] | • Good: glyphosate, fluazifop<br>• Poor: 2,4-D, dicamba, picloram | • Several years | • Most herbicides control broad leaf plants, selection of grass selective herbicide is necessary<br>• Most grass herbicides will also kill desirable native grasses, use backpack sprayer to target plants |
| | | • Biological | • Early spring | • Grazing | • Several years | • Goats prefer forbs, but will consume young shoots if nothing else is available |
| | | • Mechanical | • Early spring following germination | • Removal | • Several Years | • The entire plant and all runners must be removed |
| Common teasel (*Dipsacus fullonum*) | • Biennial or short-lived perennial | • Chemical | • Spring to summer when plants are bolting | • Good: metsulfuron, dicamba | • Several years | • Follow label instructions, rosettes requires less concentrated herbicide than flowering plants |

| Common Name (*Scientific Name*) | Reproduction Characteristics | Control Methods | Application Timing | Application Method | Duration Of Treatment | Treatment Remarks |
|---|---|---|---|---|---|---|
| | • Reproduces by seed, each plant produces over 2,000 seeds<br>• Seeds viable in soil for 2-3 years | • Biological | • None available | • None available | • None available | • None available |
| | | Mechanical | • Summer before seed set | • Mowing or cutting | • Several years | • Effective for small infestations<br>• Exhaust seed bank after several years |
| Russian olive (*Elaeagnus angustifolia*) | • Perennial tree<br>• Reproduce from seed | • Chemical | • Foliar application when leaves have fully flushed<br>• Cut-stump application can occur year round[1] | • Good:2,4-D, imazapyr, triclopyr | • 1 to 2 seasons | • Apply 2,4-D when leaves are fully developed, 2-3 retreatments may be necessary<br>• Apply imazapyr or triclopyr for spot foliar treatments, basal bark or cut-stump methods; stump applications should be made as soon after cutting as possible |
| | | • Biological | • Spring, summer | • Goats | • Limited to sprouts and low foliage | • Goats graze flowers, fruits, and leaves |
| | | • Mechanical | • Spring | • Hand-pull seedlings and sprouts | • Several years | • Cutting or burning not recommended as they stimulate more growth |
| Quackgrass (*Elymus repens*) | • Propagates mainly by rhizomes but also reproduces by seed; flowers from June through August; seeds remain viable for up to 10 years | • Chemical | • Early flowering stage or new growth in the fall[1] | • Good: glyphosate, fluazifop<br>• Poor: 2,4-D, dicamba, picloram<br>• Unrated: sethoxydim, atrazine | • Several years | • Do not apply fluazifop to stressed quackgrass as treatment effectiveness will be reduced |
| | | • Biological | • Early spring | • Grazing | • Several years | • Goats prefer forbs, but will graze young shoots if nothing else is available |
| | | • Mechanical | • Before flowering | • Mowing | • Ongoing | • Will not eliminate infestation, but will reduce seed set |
| Leafy spurge (*Euphorbia esula*) | • Primary reproduction is vegetative through lateral root system<br>• Seeds can remain viable in the soil for 5 to 8 years, although 99% of the viable seeds will germinate in the first two years | • Chemical | • Early spring from bud to early flowering<br>• Apply imazapic in the late fall before it loses its milky sap and after a killing frost[1] | • Good: picloram, glyphosate, imazapic<br>• Fair: 2,4-D, dicamba, glyphosate, imazapic+glyphosate, dicamba+2,4-D<br>• Poor: 2,4-D, 2,4-D+clopyralid, metsulfuron | • Requires repeat applications in one season | • Rapid re-establishment of treated stands often occurs after an apparently successful management effort because of the large nutrient reserve stored in the roots of leafy spurge plants<br>• Extend herbicide 15 feet past infestation to kill lateral roots<br>• 2,4-D and glyphosate have shown mixed results, and should be applied carefully according to label instructions regarding application requirements and restrictions |
| | | • Biological | • Spring and summer when plants are succulent | • Grazing | • Ongoing | • Removal of goats will result in re-establishment of leafy spurge<br>• Goats will seek out leafy spurge |
| | | • Mechanical | • Ongoing | • Mowing | • Several years | • Mowing will reduce seed set, but not control infestation<br>• Tilling not recommended as cut roots will regenerate |
| Myrtle Spurge (*Euphorbia myrsinites*) | • Perennial<br>• Reproduces from seed, but regrowth from cut roots has been observed | • Chemical | • Spring: seedling stage | • Good: 2,4-D, dicamba, glyphosate<br>• Fair: picloram | • Several years | • Combine herbicide and mechanical control for best results<br>• Deplete soil seed bank |
| | | • Biological | • None available | • None available | • None available | • Toxic to animals<br>• Used in landscaping as a deer deterent |
| | | • Mechanical | • Before seed set | • Removal | • Several years | • Effective for small infestations |
| Dyers woad (*Isatis tinctoria*) | • Biennial<br>• Reproduces from seed | • Chemical | • April-June, at or during first bloom when plants are vigorous and before seed set[1] | • Excellent: dicamba, metsulfuron<br>• Good: 2,4-D, glyphosate, imazapic, chlorsulfuron | • Several years to deplete seed supply in soil | • Prevent seedling growth<br>• Prevent spread of weed<br>• Yearly summer monitoring |

| Common Name (*Scientific Name*) | Reproduction Characteristics | Control Methods | Application Timing | Application Method | Duration Of Treatment | Treatment Remarks |
|---|---|---|---|---|---|---|
| | | | | • Fair: dicamba | | • Do not apply during periods of intense rainfall, or to soils saturated with water<br>• Best to apply when ground is moist<br>• Dicamba has shown mixed results, and should be applied carefully according to label instructions regarding application requirements and restrictions |
| | | • Biological | • April-June, at or during first bloom when plants are vigorous and before seed set | • Rust fungus (*Puccinia thlaspeos*)<br>• Grazing | • Several years to deplete seed supply in soil | • Reduce or prevent seed production<br>• Prevent seedling growth or survival<br>• Yearly summer monitoring<br>• Plants regenerate from roots after leaves are removed, grazing must be repeated |
| | | • Mechanical | • April-June, at or during first bloom when plants are vigorous and before seed set<br>• Mowing: ongoing | • Removal<br>• Mowing | Several years to deplete seed supply in soil | • Removal is simplest and most effective method of control<br>• Bag – O – Woad program organized through local CWMA to remove plants<br>• Plants regenerate from roots after leaves are removed, mowing must be repeated throughout growing season |
| Perennial pepperweed (*Lepidium latifolium*) | • Perennial<br>• Stems originate from large perennial belowground roots in early spring or late fall<br>• Seeds lack a hard coat and do not seem to be capable of surviving long periods in the soil, thus seed viability may be short | • Chemical | • Spring, between flowerbud and early flowering or to resprouted leaves after mowing<br>• Fall, re-apply after dormant roots sprout and bud | • Excellent: Chlorsulfuron, metsulfuron<br>• Good: dicamba, glyphosate, chlorsulfuron, metsulfuron, imazapic, imazapyr<br>• Fair: 2,4-D, picloram, triclopyr | • 1 year with up to several years of monitoring and spot spraying if disking, mowing, and spraying | • Combine disking, mowing, and herbicide application<br>• Disk in the fall to fragment roots<br>• Mow between flowerbud and flowering<br>• Apply herbicide to resprouted leaves, 2-3 weeks after mowing<br>• Use chlorsulfuron or metsulfuron on dry land, and glyphosate or imazapyr over water<br>• Seed exposed soil with desirable perennial plants<br>• Monitor for recurrence in early spring and late summer for several years following treatment |
| | | • Biological | • Spring, rosette stage | • Grazing | • Ongoing, grazing suppresses seed production but does not kill plants | • Permanent grazing will suppress plants; plants resprout quickly when grazing is removed<br>• Foliate may be poisonous to cattle<br>• Dense stands may be difficult to graze |
| | | • Mechanical | • Fall, disk to fragment roots<br>• Spring, mow between flowerbud and flowering<br>• Continuous, flooding | • Disking<br>• Mowing<br>• Flooding<br>• Burning | • Flooding-ongoing<br>• 1 year with up to several years of monitoring and spot spraying if disking, mowing, and spraying | • Combine disking, mowing, and herbicide application<br>• Disk in the fall to fragment roots, disking alone increases infestation by resprouting from fragmented roots<br>• Mow in the spring between flowerbud and flowering, mowing alone stimulates growth<br>• Apply herbicide to resprouted leaves, 2-3 weeks after mowing depending on soil moisture<br>• Seed exposed soil with desirable perennial plants<br>• Monitor for recurrence in early spring and late summer for several years following treatment<br>• Burning not effective as it does not harm roots and allows resprout, but may be used to remove excessive litter buildup<br>• Flooding for 2 consecutive seasons is effective by increasing competition from flood adapted plants |
| Dalmation toadflax (*Linaria dalmatica*) | • Perennial<br>• Reproduces from seed | • Chemical | • Summer, full bloom | • Good: dicamba, picloram, glyphosate, imazapic, chlorsulfuron,<br>• Fair: metsulfuron, 2,4-D<br>• Poor: 2,4-D, dicamba | • Several years | • Seed area with competitive annual and perennial grasses Minimize soil disturbance<br>• Aggressive cultivation could control an area after several seasons but monitoring must continue for 10 to 15 years<br>• Dicamba and 2,4-D have shown mixed results, and should be applied carefully according to label instructions regarding application |

| Common Name (*Scientific Name*) | Reproduction Characteristics | Control Methods | Application Timing | Application Method | Duration Of Treatment | Treatment Remarks |
|---|---|---|---|---|---|---|
| | | | | | | requirements and restrictions |
| | | • Biological | • Spring and summer | • Grazing<br>• Toadflax flower-feeding beetle (*Brachypterolus pulicarius*)<br>• Toadflax moth (*Calophasia lunula*)<br>• Toadflax root-boring moth (*Eteobalea intermediella*)<br>• Toadflax seed capsule weevil (*Gymnetron antirrhini*)<br>• Toadflax root-galling weevil (*Gymnetron linariae*)<br>• Toadflax stem weevil (*Mecinus janthinus*) | • Several years | • Grazing can be effective if continued to prevent rebolt and seed set<br>• Sheep and goats prefer Dalmatian toadflax to other rangeland grasses<br>• Many insects attack both Dalmatian toadflax and yellow toadflax |
| | | • Mechanical | • Spring and before seed set | • Fire followed by herbicide application | • Several years | • Pulling not advised as plants develop extensive root systems (up to 2 m deep) that have dormant buds that can reproduce vegetatively |
| Purple Loosestrife (*Lythrum salicaria*) | • Perennial<br>• Reproduces primarily by seed, as well as creeping rootstocks and cut stems | • Chemical | • Spring, apply when weeds are actively growing | • Good: 2,4-D, metsulfuron, glyphosate | • Several years | • Purple loosestrife often grows near riparian areas, and aquatic formulations of the recommended herbicides are available |
| | | • Biological | • Early spring, adults feed on buds | • black-margined loosestrife beetle (*Galerucella calmariensis*)<br>• golden loosestrife beetle (*Galerucella pusilla*)<br>• loosestrife root weevil (*Hylobius transversovittatus*)[5]<br>• loosestrife seed weevil (*Nanophyes marmoratus*)[5] | • 2 years | • The beetles can feed on two native plants (*Decodon verticillatus* and *Lythrum alatum*) and two introduced plants (*L. hyssopifolia* and *Lagerstroemia indica*), but do not reproduce on these hosts |
| | | • Mechanical | • Before seed set | • Removal | • Several years | • Tilling and mowing not recommended as cut roots and stems can resprout<br>• Bag or burn removed plants |
| Phragmites (*Phragmites australis*) | • Perennial<br>• Reproduces primarily from rhizomes<br>• Seeds are often not viable | • Chemical | • Fall, after tasseling | • Good: glyphosate, imazapyr,<br>• Poor: 2,4-D, dicamba, picloram | • Several years | • Use the aquatic formulation to avoid harm to wildlife |
| | | • Biological | • Spring, summer | • Grazing | • Several years | • Cattle will graze phragmites, but do not like standing water<br>• Goats will graze phragmites, but water level must be below 4 inches |
| | | • Mechanical | • Fall | • Burning | • Several years | • Dead phragmites stands prohibit new growth of desirable plants, and must be removed<br>• Burning without herbicide treatment could result in more vigorous stands |
| Buffalobur (*Solanum rostratum*) | • Annual<br>• Reproduces from seed, self-pollinates | • Chemical | • Spring before bloom | • Unrated: 2,4-D | • Several years | • Most effective if following mowing |
| | | • Biological | • None available | • None available | • None available | • Contains the alkaloid solanine, which is toxic to livestock<br>• Sharp burs can damage mouth |
| | | • Mechanical | • Spring and Summer | • Pulling<br>• Mowing | • Several Years | • This is not a very competitive species, and pulling plants offers good control as the seed bank is depleted<br>• Mowing followed by herbicide application offers the best control |

| Common Name (*Scientific Name*) | Reproduction Characteristics | Control Methods | Application Timing | Application Method | Duration Of Treatment | Treatment Remarks |
|---|---|---|---|---|---|---|
| Johnsongrass (*Sorghum halepense*) | • Perennial<br>• Colonization can occur from both rhizomes and seed, and seeds can remain viable for over 2 years in the soil | • Chemical | • Spring, apply to actively growing vegetation[1] | • Excellent: glyphosate<br>• Good: glyphosate, fluazifop<br>• Poor: 2,4-D, dicamba, picloram<br>• Unrated: sulfometuron methyl | • Several years | • Many herbicides are broadleaf specific, read label to be sure correct formulation is used for grasses<br>• Grass selective herbicides may kill desirable grasses<br>• Glyphosate has shown mixed results, and should be applied carefully according to label instructions regarding application requirements and restrictions |
| | | • Biological | • Early spring before flowering | • Grazing | • Several years | • Be careful to remove grazers as Johnsongrass becomes toxic under moisture stress |
| | | • Mechanical | • Early spring when soil is moist for hand pulling<br>• Several times over the growing season | • Hand pulling<br>• Mowing | • Several years for mowing to remove root reserves | • Be careful not to spread Johnsongrass when removing or mowing as root pieces can resprout |
| Tamarisk (*Tamarix ramosissima*) | • Perennial tree | • Chemical | • Use cut-stump method in the fall. Apply herbicide to entire circumference of cambium within one minute of cutting. Up-rooting or chaining not recommended as it may only encourage vigorous re-sprouting<br>• Spay respouted foliage 4 to 12 months after initial treatment [1] | • Unrated: glyphosate | • 1 year with follow-up annual monitoring and re-treatment | • Be prepared to apply herbicide immediately after cutting (works best if one person operates chain saw and a second person applies herbicide)<br>• Wait at least 4 months before treating re-sprouted foliation<br>• Monitor annually for success of treatment and for new areas to control<br>• Focus on younger stands and sprouts first |
| | | • Biological | • Best results if adults are gathered in July and allowed to lay eggs in the new location before winter | • Leaf beetle (*Diorhabda elongata*) | • 2 to 3 seasons | • Large populations (10,000 individuals) introduced at one time reduces bird and ant predation effects |
| | | • Mechanical | • Spring and summer | • Cutting | • 1 to 2 years | • Not recommended because roots and shoots resprout without herbicide application |
| Medusahead (*Taeniatherum caput-medusae*) | • Annual<br>• Reproduces entirely from seed; up to 6,000 seeds/ft$^2$ | • Chemical | • Spring, apply to actively growing vegetation[1] | • Good: glyphosate, fluzifop<br>• Poor: 2,4-D, dicamba, picloram<br>• Unrated: sulfometuron methyl | • Several years | • Many herbicides are broadleaf specific, read label to be sure correct formulation is used for grasses<br>• Grass selective herbicides may kill desirable grasses |
| | | • Biological | • Early spring | • Grazing | • Several years | • Cattle and goats will graze when plants are green<br>• Seeds cause damage to eyes and mouth |
| | | • Mechanical | • After plant senesced and before seed is disseminated | • Burning | • Several years to deplete soil seed bank | • Slow burn will destroy seeds, but other weeds may colonize after fire |
| Puncturevine (*Tribulus terrestris*) | • Annual<br>• Reproduces from seed | • Chemical | • Summer, before bloom | • Good: 2,4-D, imazapic, chlorsulfuron<br>• Fair: picloram | • Several years | • Continue control to exhaust soil seed bank |
| | | • Biological | • None available | • None available | • None available | • The puncturevine seed weevil and stem weevil are available in warm climates without cold winters; not suitable for this climate<br>• Grazing spiny fruits can cause injury to the mouths and digestive tracts of livestock |
| | | • Mechanical | • Spring before seed set | • Removal | • Several years | • Remove entire plant for small infestations |

CSU 2000, Lyons 2006, TNC 2006, USU 2004

# APPENDIX D. SMALL MAMMAL TRAPPING PROTOCOL

## INTRODUCTION

The purpose of live small mammal trapping surveys at the LNP is to assess the diversity and abundance of different rodent species present within the different habitats found on the LNP. This trapping method provides information about species diversity, while limiting the trapper's direct exposure to the captured animals. This helps to minimize and avoid transfer of diseases from rodent to human or vice versa. The following protocol should be followed when conducting small mammal surveys at LNP, to remain consistent and provide comparable data from year to year.

## SETTING UP THE TRAP ARRAY

Most small mammal surveys follow the same design for setting up trapping arrays across a landscape. Larger studies generally consist of a 10x10 grid array of traps placed 10 meters apart from each other. These traps are checked each morning after 3 consecutive nights of activating traps. This size array can be easily maintained and checked when there is more then one surveyor. However, at LNP resources and man-hours are somewhat constrained, and a number of habitats require surveying. For these reasons, we suggest creating a smaller trap array of 5x10, or 50 traps total, that is repeatable over several habitats. An array of 50 traps can be set and checked for 3 days by one or two people, and will provide LNP managers with enough data to compare between years. Ideally, 10x10 trap arrays with 100 traps total should be used if time and man-hours are available.

Generally speaking, the type of trap used for small mammal surveys are aluminum Sherman Live Capture Traps (3"x 3.5"x 9") (http://www.shermantraps.com). This trap comes in several different models (folding and non-folding, galvanized steel or all aluminum, ventilated and non-ventilated) and there are several generics on the market. However, we recommend the folding aluminum models without ventilation holes, as they are easier to transport and clean. The unventilated traps also hold warmth better than the ventilated traps, and cool nights are of more concern than overheating traps when they are set in the Great Basin region during late summer or early fall months.

When attempting to catch larger mammal species at a particular trap site, a Sherman trap can be replaced with a Tomahawk live trap (http://www.livetrap.com/). These are larger, woven wire traps that come in various sizes. It is recommended that only smaller traps are set at LNP (either Sherman or Tomahawk 5x5x16" which are suitable for chipmunks, rats, gophers), to avoid accidental capture of skunks. Live release of skunks from such a trap without being sprayed is nearly impossible.

Surveyors should always have extra traps with them when setting up and checking the array! This will ensure that should a trap be damaged or otherwise useless, there will still be enough functioning traps to cover the entire grid. Sherman traps have a few small wire parts that may rust and break over time. Parts can be ordered from the trap company and several mail order catalogs to replace these parts. Always avoid being caught in the field unprepared to replace broken traps by having several spares!

Site selection depends on what data is desired from the trapping exercise. In the case of LNP, the initial goal will be to record what small mammal species are present within a

particular habitat. The long-term goal is then to repeat the trapping effort each year, to determine if species types and relative abundance are changing over time, potentially due to different management practices. For baseline information, one 5x5 and one 5x10 trap array will be set up in 2 of the habitats at LNP to compare differences in small mammal diversity (if any) between the different ecological communities. For the first season, one trap array will be set in a grassland habitat, and one in an alkaline knoll habitat. If smaller trap arrays are unsuccessful, then larger trap arrays will be used for future surveys. Trapping in the other habitats present at LNP should be initiated in a future seasons, following this pilot study. Similarly, future studies may also investigate relative abundance of small mammal species using mark-recapture methods. Protocols for studies collecting new types of data will be outlined in a separate document.

Timing is an important issue when conducting a small mammal survey. Late summer and early fall are the most ideal times to trap rodents, as they are less likely to have young. This will minimize the effects that the survey has on the rodent population and its reproductive success. Any females caught should be checked for lactation, which would indicate the presence of young. "Wet" females should be processed and released as quickly as possible to return to their litter.

Setting up the trap array is best accomplished using two people, though one person can also set up an array, but with less efficiency. Trap arrays should be set up at least 5-7 days in advance of baiting. This will allow time for animals to acclimate to the presence of traps prior to the traps being set. Traps are left with the door closed on these initial days to avoid accidental trappings. The corners of the trap grid should either be posted with a permanent feature, such as a t-post or PVC stake, and GPS coordinates should be taken at each corner to eliminate the presence of human structures that are visible on the landscape, and to have a record of the exact location of the trap array (for GPS coordinates please use UTMs, NAD 83 datum). A plastic tape measure should be used to measure 10 meters between each trap location. Each trap location in the grid is then marked temporarily with flagging tape or wire stakes with vinyl flagging. Some liberty can be taken on a smaller scale to decide where to place each trap, to increase the chance of successful capture at that site. For example, if a rodent burrow is found a couple of feet away from a trap point, the trap can be placed closer to the burrow in the hopes of capturing that individual.

## BAITING TRAPS

Bait for traps can be prepared a day or two in advance so that it is ready to go on the first day of trapping. Usually it is most convenient to make enough bait to last the whole 3 days of the survey, so that it is not of concern during the survey itself. To make bait, simply mix peanut butter and rolled oats to create a mix that has the approximate consistency of modeling clay. Roll chunks of the bait into small, dime or nickel sized balls. To reduce mess in the traps, each ball of bait can be wrapped with a perforated piece of wax paper. This basic recipe can be modified to include other ingredients, in order to attract a wider variety of small mammals. For instance, beef or chicken bullion can be crushed and mixed into the bait to attract shrews. For LNP, a mix of bullion, peanut butter, and rolled oats will be used in the hopes of attracting as wide a variety of small mammals as possible.

Traps should be baited in the evening, as close to dark as possible to minimize the time an animal spends in the trap before morning checks for captured individuals. To bait traps, open the front door on each trap to set. Test the sensitivity of the treddle at the back of the trap by pressing lightly on the back door or treddle to trip the spring (depends upon which model trap you are using). Adjust the sensitivity of the trap as needed by bending the treddle arm slightly against or away from the front door of the trap. Once the proper sensitivity is achieved, drop a ball of bait and several cotton balls into the back of the trap. Ideally, the bait should be sitting on top of the treddle. The cotton balls are meant to provide overnight insulation for a captured mammal, and do not necessarily need to be on the treddle when the trap is set. Gently place the trap with the front door open on the ground. The opening can and should be placed towards any nearby burrows, to encourage capture. Traps can then be covered with ground litter or debris if desired. This will insulate the trap a bit better, but it will also make the trap more difficult to relocate in the morning. The surveyor can make this judgment on a case-by-case basis.

## CHECKING TRAPS

Traps are to be checked by surveyors as soon after sunlight as possible, to minimize the time an animal spends in the trap. This is of course to reduce stress and fatalities of any small mammals during trapping sessions. During trap checks, surveyors should wear disposable rubber gloves to protect against diseases carried by rodents. Larger mammals may require the use of leather gloves to protect from bites. Direct handling of animals in this type of survey should be minimized, as there is no need to directly handle the animal to identify it to species in most cases. Instead, use a gloved hand to hold the front door of the trap open, and tip it at an angle into a quart-sized ziplock baggie with holes punched into it. This will allow the surveyor to view the animal without having to handle it. Be sure to have several baggies on hand for use, as one may eventually tear or become soiled. Take enough time to positively identify the species caught, and if possible, check gender and reproductive status for females (lactating or not). Record the data on the data sheet (see the end of this document for a template), open the ziplock bag, and release the rodent as close to the capture point as possible. Replace the trap to its spot on the ground, leaving the doors closed to avoid new captures during the day. Traps will be rebaited if necessary, and set again later in the evening once again. A total of three consecutive trap nights is typical for this type of survey.

Leather gardening gloves should be carried as they can be as well. There may be some cases where surveyors must handle the animal caught, to coax it out of the trap, ziplock, or other cases where thicker gloves will be handy. Leather gloves will also help to avoid scratches or bites in cases where larger rodents or mammals are caught that do not fit into the ziplock bag for processing.

## RECORDING DATA

The data form attached at the end of this document should be used to collect all the necessary and useful data for small mammal trapping surveys. Often in the field it is most efficient to have two people running trap checks. This way one person can conduct the trap handling while the other records all the data. Any rodents that perish in the traps prior to a morning check can be collected in a plastic bag and examined more closely

later, if it is desired by the surveyor(s). For example, vole species can be difficult to identify by sight, and often perish in traps due to their high metabolism. If a dead shrew or other species is found during a trapping survey, it can be taken back to a lab situation, where the dentition can be studied more closely to determine species. To understand dental formulas and key out mammal dentition, please see "A Key to the Skulls of North American Mammals" by Bryan P. Glass and Monte L. Thesis.

## REFERENCES

Glass, Bryan P., and Monte L. Thies. 1997. "A Key to the Skulls of North American Animals". 3rd Edition.

Mammal Trapping Guide: http://www.stolaf.edu/depts/environmental-studies/courses/es-399%20home/es-399-05/Projects/Jared's%20Senior%20Seminar%20Research%20Page/htt.htm

Sherman Live Traps Company: http://www.shermantraps.com

Tomahawk Live Traps Company: http://www.livetrap.com

# Mammal Trapping Survey Data

**Date: _____**

**Weather: _____**

**Array UTMS: _____**

**Habitat Type: _____**

| Trap # | Species | Sex | Lactating? | Comments |
|---|---|---|---|---|
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# APPENDIX E. DESIRED PLANT SPECIES

| TABLE NOTES | | |
|---|---|---|
| OBL | Obligate Wetland | Occurs almost always (estimated probability 99%) under natural conditions in wetlands. |
| FACW | Facultative Wetland | Usually occurs in wetlands (estimated probability 67%-99%), but occasionally found in non-wetlands. |
| FAC | Facultative | Equally likely to occur in wetlands or non-wetlands (estimated probability 34%-66%). |
| FACU | Facultative Upland | Usually occurs in non-wetlands (estimated probability 67%-99%), but occasionally found on wetlands (estimated probability 1%-33%). |
| UPL | Obligate Upland | Occurs in wetlands in another region, but occurs almost always (estimated probability 99%) under natural conditions in non-wetlands in the regions specified. If a species does not occur in wetlands in any region, it is not on the National List. |
| NI | No indicator | Insufficient information was available to determine an indicator status. |

## Freshwater Marsh*

| Scientific name | Common name | Wetland indicator status | Emergent marsh | Wet meadow |
|---|---|---|---|---|
| *Alopecurus aequalis* | shortawn foxtail | OBL | X | X |
| *Beckmannia syzigachne* | American sloughgrass | OBL | X | X |
| *Carex praegracilis, lanuginosa, nebrascensis* | sedge | OBL- FACW | X | X |
| *Catabrosa aquatica* | water whorlgrass | OBL | X | |
| *Deschampsia caespitosa* | tufted hairgrass | FACW | | X |
| *Eleocharis palustris* | common spikerush | OBL | X | X |
| *Eleocharis acicularis, macrostachya, parishii, parvula,* or *rostellata* | other spikerushes | OBL- FACW | X | X |
| *Juncus arcticus* | arctic rush | FACW | X | X |
| *Juncus torreyi* | Torrey's rush | FACW+ | X | |
| *Leymus triticoides* | beardless wildrye | FAC+ | | X |
| *Muhlenbergia asperifolia* | scratchgrass | FACW+ | | X |
| *Puccinellia nuttalliana* | Nuttall's alkaligrass | OBL | | X |
| *Schoenoplectus acutus* | hardstem bulrush | OBL | X | |
| *S. americanus* | Olney's threequare | OBL | X | |
| *S. maritimus* | alkali bulrush | NI | X | |
| *S. tabernaemontani* | softstem bulrush | OBL | X | |
| *Sporobolus airoides* | alkali sacaton | FAC | | X |

*Submergent marsh sub-habitat class would not need to be seeded.

## Grassland

| Scientific name | Common name | Wetland indicator status | Tall grass | Short grass |
|---|---|---|---|---|
| *Achnatherum hymenoides* | Indian ricegrass | UPL | X | |
| *Bouteloua gracilis* | blue grama | NI | | X |
| *Distichlis spicata* | saltgrass | FAC+* | | |
| *Elymus canadensis* | Canada wildrye | FACU | X | |
| *Elymus elymoides* | squirreltail | UPL | X | X |
| *Elymus glaucus* | blue wildrye | FACU | X | |
| *Elymus spicatus* | bluebunch wheatgrass | UPL | X | |
| *Eragrostis pectinacea* | purple lovegrass | NI | X | X |
| *Festuca rubra* | red fescue | FAC | | X |
| *Hesperostipa comata* | needle-and-thread grass | NI | X | X |
| *Hordeum pusillum* | little barley | FAC | X | X |
| *Koeleria macrantha* | prairie junegrass | NI | | X |
| *Leymus cinereus* | basin wildrye | NI | X | X |
| *Pascopyrum smithii* | western wheatgrass | FACU | | X |
| *Poa secunda* | Sandberg bluegrass | UPL | | X |
| *Pleuraphis jamesii* | James' galleta | NI | | X |
| *Pseudoroegneria spicata* | bluebunch wheatgrass | UPL | | |
| *Sphaeralcea coccinea* | Scarlet globemallow | NI | X | X |
| *Sporobolus airoides* | alkali sacaton | FAC | X | |
| *Sporobolus cryptandrus* | sand dropseed | FACU- | X | |
| *Thinopyrum intermedium* | intermediate wheatgrass | NI | X | |

## Riparian

| Scientific name | Common name |
|---|---|
| *Calamagrostis canadensis* | bluejoint |
| *Carex lanuginosa* | wooly sedge |
| *Ribes aureum* | golden currant |
| *Salix amygdaloides* | peachleaf willow |
| *Salix bebbiana* | Bebb willow |
| *Spartina pectinata* | prairie cordgrass |

### Salt-affected floodplain

| Scientific name | Common name | Wetland indicator status |
|---|---|---|
| *Deschampsia caespitosa* | tufted hairgrass | FACW |
| *Eleocharis palustris* | common spikerush | OBL |
| *Muhlenbergia asperifolia* | scratchgrass | FACW+ |
| *Puccinellia nuttalliana* | Nuttall's alkaligrass | OBL |
| *Sporobolus airoides* | alkali sacaton | FAC |

### Alkaline Knolls habitat*

| Scientific name | Common name | Wetland indicator status | Salt meadow |
|---|---|---|---|
| *Achnatherum hymenoides* | Indian ricegrass | UPL | |
| *Artemisia ludoviciana* | white sagebrush | FACU | |
| *Artemisia tridentata* | sagebrush | NI | |
| *Atriplex canescens* | four-wing saltbush | UPL | |
| *Atriplex confertifolia* | shadscale saltbush | NI | |
| *Atriplex cuneata spp. cuneata* | valley saltbush | NI | |
| *Atriplex falcata* | sickle saltbush | FACW* | |
| *Deschampsia caespitosa* | tufted hairgrass | FACW | X |
| *Elymus canadensis* | Canada wildrye | FACU | |
| *Elymus elymoides* | squirreltail | UPL | |
| *Grayia spinosa* | spiny hopsage | NI | |
| *Hesperostipa comata* | needle-and-thread grass | NI | |
| *Krasheninnikovia lantana* | winterfat | NI | |
| *Leymus cinereus* | basin wildrye | NI | |
| *Leymus triticoides* | creeping wildrye | FAC+ | X |
| *Picrothamnus desertorum* | bud sagebrush | NI | |
| *Poa secunda* | Sandberg bluegrass | UPL | |
| *Puccinellia nuttalliana* | Nuttall's alkaligrass | OBL | X |
| *Pseudoroegneria spicata* | bluebunch wheatgrass | UPL | |
| *Sarcobatus vermiculatus* | greasewood | FACU* | X |
| *Sphaeralcea coccinea* | scarlet globemallow | NI | |
| *Sporobolus airoides* | alkali sacaton | FAC | X |
| *Sporobolus cryptandrus* | sand dropseed | FACU- | |
| *Triglochin maritima* | maritime arrowgrass | OBL | X |

*no seeding necessary in alkaline flats sub-habitat class.

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# APPENDIX F. PLAYA VEGETATION

## Playa Vegetation

| Scientific Name | Common name | Occurrence | Notes |
|---|---|---|---|
| *Salicornia rubra* | pickleweed | Dominant in basin, or on edge as soils exceed tolerated salinity levels and most of ground in the basin is bare | Vegetation in quadrat must include this species if it is considered a playa unless the bare ground coverage is approaching 100% |
| *Distichlis spicata* | saltgrass | Occasionally around edges, commonly dominant in areas surrounding playas. | Can occur within a quadrat that is classified as playa, but must only be present in small amounts (49% or less in when summed with other non-pickleweed species) |
| *Suaeda calceoliformis* | seepweed | Occurs in alkaline flats only | Can help define the extent of an alkaline flat |
| *Allenrolfea occidentalis* | iodinebush | Occurs in alkaline flats only | Can occur in the interior of a basin as well as in the surrounding topographically higher areas |

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# APPENDIX G. VEGETATION SURVEY LOCATIONS

## Releve Plot Center Points

| | Northing | Easting |
|---|---|---|
| A | 4522166 | 420154 |
| B | 4522160 | 420331 |
| C | 4522465 | 420210 |
| D | 4522761 | 420040 |
| E | 4523877 | 419890 |
| F | 4523862 | 419672 |

## Basin Transects

| | Start Point | | End Point | |
|---|---|---|---|---|
| | Northing | Easting | Northing | Easting |
| A-T1 | 4523053 | 418738 | 4522984 | 418733 |
| A-T2 | 4523071 | 418768 | 4522985 | 418767 |
| A-T3 | 4523033 | 418828 | 4522969 | 418831 |
| B-T1 | 4523313 | 418814 | 4523254 | 418817 |
| B-T2 | 4523323 | 418847 | 4523217 | 418847 |
| B-T3 | 4523269 | 418916 | 4523172 | 418923 |
| C-T1 | 4523329 | 419168 | 4523326 | 419245 |
| C-T2 | 4523381 | 419178 | 4523380 | 419276 |
| C-T3 | 4523477 | 419206 | 4523477 | 419261 |
| D-T1 | 4523731 | 418859 | 4523682 | 418856 |
| D-T2 | 4523767 | 418920 | 4523680 | 418918 |
| D-T3 | 4523756 | 418962 | 4523696 | 418957 |
| E-T1 | 4524278 | 418877 | 4524271 | 418927 |
| E-T2 | 4524338 | 418863 | 4524327 | 418938 |
| E-T3 | 4524393 | 418872 | 4524380 | 418934 |
| F-T1 | 4524307 | 419046 | 4524307 | 419146 |
| F-T2 | 4524352 | 419053 | 4524347 | 419129 |
| F-T3 | 4524414 | 419060 | 4524403 | 419168 |

Note- For Basins C, E, and F, start points are west and endpoints are east.
For Basins A, B, and D, start points are north and endpoints are south.

## Floodplain Transects

| | West Point | | East Point | |
|---|---|---|---|---|
| | **Northing** | **Easting** | **Northing** | **Easting** |
| T1 | 4524381 | 418754 | 4524339 | 419252 |
| T2 | 4523861 | 418823 | 4523878 | 419478 |
| T3 | 4523683 | 418668 | 4523682 | 419364 |
| T4 | 4523442 | 418720 | 4523406 | 419296 |
| T5 | 4522969 | 418623 | 4522939 | 419120 |
| T6 | 4522719 | 418723 | 4522747 | 419416 |

## Weed Transects and Photo Points 1-6

| ID | Northing | Easting | Comments |
|---|---|---|---|
| WT1a Start | 4524203 | 419065 | freshwater marsh a (emergent veg) east point |
| WT1a End | 4524191 | 419038 | freshwater marsh a (emergent veg) west point |
| WT1b Start | 4524156 | 419129 | freshwater marsh b (emergent veg) east point |
| WT1b End | 4524134 | 419107 | freshwater marsh b (emergent veg) west point |
| WT2 Start | 4524714 | 418773 | riparian transect north point |
| WT2 End | 4524673 | 418802 | riparian transect south point |
| WT3 Start | 4524778 | 420846 | freshwater marsh 1 (wet meadow veg) south point |
| WT3 End | 4524828 | 420847 | freshwater marsh 1 (wet meadow veg) north point |
| WT4 Start | 4525099 | 420619 | freshwater marsh 2 (wet meadow veg) south point |
| WT4 End | 4525096 | 420568 | freshwater marsh 2 (wet meadow veg) north point |
| WT5 Start | 4533387 | 424207 | upland transect 1 (alkaline knolls veg ) south point |
| WT5 End | 4533437 | 424196 | upland transect 1 (alkaline knolls veg ) north point |
| WT6 Start | 4524598 | 419365 | upland transect 2 (grassland veg) south point |
| WT6 End | 4524647 | 419372 | upland transect 2 (grassland veg) north point |
| WPP1 | 4524204 | 419077 | emergent marsh photo point |
| WPP2 | 4524703 | 418777 | riparian photo point |
| WPP3 | 4524778 | 420846 | wet meadow photo point 1 |
| WPP4 | 4525099 | 420619 | wet meadow photo point 2 |
| WPP5 | 4533387 | 424207 | alkaline knolls veg photo point |
| WPP6 | 4524598 | 419365 | grassland veg photo point |

# APPENDIX H. HABITAT SCHEMES

| TABLE NOTES | | |
|---|---|---|
| OBL | Obligate Wetland | Occurs almost always (estimated probability 99%) under natural conditions in wetlands. |
| FACW | Facultative Wetland | Usually occurs in wetlands (estimated probability 67%-99%), but occasionally found in non-wetlands. |
| FAC | Facultative | Equally likely to occur in wetlands or non-wetlands (estimated probability 34%-66%). |
| FACU | Facultative Upland | Usually occurs in non-wetlands (estimated probability 67%-99%), but occasionally found on wetlands (estimated probability 1%-33%). |
| UPL | Obligate Upland | Occurs in wetlands in another region, but occurs almost always (estimated probability 99%) under natural conditions in non-wetlands in the regions specified. If a species does not occur in wetlands in any region, it is not on the National List. |
| NI | No indicator | Insufficient information was available to determine an indicator status. |

## Expected Plant Species for the Alkaline Knolls Habitat[1]

| Scientific name | Common name | Wetland indicator status | Sub habitat: | |
|---|---|---|---|---|
| | | | Alkaline Flat | Salt meadow |
| *Achnatherum hymenoides* | Indian ricegrass | UPL | | |
| *Allenrolfea occidentalis* | iodinebush | FACW | X | X |
| *Artemisia tridentata* | sagebrush | NI | | |
| *Atriplex canescens* | four-wing saltbush | UPL | | |
| *Atriplex confertifolia* | shadscale saltbush | NI | | |
| *Atriplex cuneata* spp. *cuneata* | valley saltbush | NI | | |
| *Atriplex falcata* | sickle saltbush | FACW* | | |
| *Chenopodium rubrum* | red goosefoot | OBL | | X |
| *Distichlis spicata* | saltgrass | FAC+* | | X |
| *Deschampsia caespitosa* | tufted hairgrass | FACW | | X |
| *Elymus elymoides* | squirreltail | UPL | | |
| *Grayia spinosa* | spiny hopsage | NI | | |
| *Gutierrezia sarothrae* | broom snakeweed | FACU | | |
| *Hesperostipa comata* | needle-and-thread grass | NI | | |
| *Hordeum pusillum* | little barley | FAC | | X |
| *Krasheninnikovia lantana* | winterfat | NI | | |
| *Leymus cinereus* | basin wildrye | NI | | |
| *Leymus triticoides* | creeping wildrye | FAC+ | | X |
| *Picrothamnus desertorum* | bud sagebrush | NI | | |
| *Poa secunda* | Sandberg bluegrass | UPL | | |

[1] Plant list partially adapted from Keate, Moderately saline (EC 7.5 to 22.5 dS) seasonal depressions.

## Expected Plant Species for the Alkaline Knolls Habitat[1]

| Scientific name | Common name | Wetland indicator status | Sub habitat: | |
|---|---|---|---|---|
| | | | Alkaline Flat | Salt meadow |
| *Puccinellia nuttalliana* | Nuttall's alkaligrass | OBL | | X |
| *Salicornia rubra* | pickleweed | OBL | X | |
| *Sarcobatus vermiculatus* | greasewood | FACU* | | X |
| *Sphaeralcea coccinea* | scarlet globemallow | NI | | |
| *Sporobolus airoides* | alkali sacaton | FAC | | X |
| *Sporobolus cryptandrus* | sand dropseed | FACU- | | |
| *Suaeda calceoliformis* | Pursh seepweed | FACW | X | |
| *Thinopyrum intermedium* | Intermediate wheatgrass | NI | | |
| *Triglochin maritima* | maritime arrowgrass | OBL | | X |

## Expected Plant Species for the Grassland Habitat

| Scientific name | Common name | Wetland indicator status | Tall grass | Short grass |
|---|---|---|---|---|
| Achnatherum hymenoides | Indian ricegrass | UPL | X | |
| Bouteloua gracilis | blue grama | NI | | X |
| Distichlis spicata | saltgrass | FAC+* | | X |
| Elymus elymoides | squirreltail | UPL | X | X |
| Elymus spicatus | bluebunch wheatgrass | UPL | X | |
| Eragrostis pectinacea | purple lovegrass | NI | X | X |
| Festuca rubra | red fescue | FAC | | X |
| Hesperostipa comata | needle-and-thread grass | NI | X | X |
| Hordeum pusillum | little barley | FAC | X | X |
| Koeleria macrantha | prairie junegrass | NI | X | X |
| Leymus cinereus | basin wildrye | NI | X | X |
| Pascopyrum smithii | western wheatgrass | FACU | X | X |
| Poa secunda | Sandberg bluegrass | UPL | | X |
| Pleuraphis jamesii | James' galleta | NI | X | X |
| Sphaeralcea coccinea | Scarlet globemallow | NI | X | X |
| Thinopyrum intermedium | intermediate wheatgrass | NI | X | |

The following invasive/non-native/cosmopolitan species may be impossible to eradicate and are therefore expected to be found in the plant species composition: *Atriplex micrantha* (orache), *Avena sativa* (common oats), Bromus *japonicus* (Japanese brome), *Bromus tectorum* (cheatgrass), *Grindelia squarrosa* (curlycup gumweed), *Lactuca serriola* (prickly lettuce), *Lepidium perfoliatum* (clasping pepperweed), *Melilotus officinale* (yellow sweetclover), *Poa bulbosa* (bulbous bluegrass), Polygonum ramosissimum (bushy knotweed), and *Rumex crispus* (curly dock).

## Expected Plant Species for the Freshwater Habitat [2]

| Scientific name | Common name | Wetland indicator status | Sub habitat: | | |
|---|---|---|---|---|---|
| | | | Submergent wetland | Emergent wetland[3] | Wet meadow |
| *Alopecurus aequalis* | shortawn foxtail | OBL | | X | X |
| *Beckmannia syzigachne* | American sloughgrass | OBL | | X | X |
| *Carex praegracilis, lanuguinosa, nebrascensis* | sedge | OBL- FACW | | X | X |
| *Catabrosa aquatica* | water whorlgrass | OBL | | X | |
| *Ceratophyllum demersum* | coon's tail | OBL | X | | |
| *Chenopodium rubrum* | red goosefoot | OBL | | X | X |
| *Deschampsia caespitosa* | tufted hairgrass | FACW | | | X |
| *Distichlis spicata* | saltgrass | FAC+* | | | X |
| *Eleocharis palustris* | common spikerush | OBL | | X | X |
| *Eleocharis acicularis, macrostachya, parishii, parvula*, or *rostellata* | other spikerushes | OBL- FACW | | X | X |
| *Hordeum jubatum* | foxtail barley | FAC* | | | X |
| *Hordeum pusillum* | little barley | FAC | | | X |
| *Juncus arcticus* | arctic rush | FACW | | X | X |
| *Leymus triticoides* | beardless wildrye | FAC+ | | | X |
| *Muhlenbergia asperifolia* | scratchgrass | FACW+ | | | X |
| *Potomogeton* spp. | potomogeton | OBL | X | | |
| *Puccinellia nuttalliana* | Nuttall's alkaligrass | OBL | | | X |
| *Schoenoplectus acutus* | hardstem bulrush | OBL | | X | |
| *S. americanus* | Olney's threequare | OBL | | X | |
| *S. maritimus* | alkali bulrush | NI | | X | |
| *S. tabernaemontani* | softstem bulrush | OBL | | X | |
| *Sporobolus airoides* | alkali sacaton | FAC | | | X |
| *Stuckenia filiformis* | sago pondweed | OBL | X | | |

The following invasive/non-native/cosmopolitan species may be difficult to eradicate and are therefore expected to be found in the plant species composition: *Agrostis stolonifera* (creeping redtop bentgrass), *Atriplex micrantha* (orache), *Bassia hyssopifolia* (bassia), *Bromus japonicus* (Japanese brome), *Bromus tectorum* (cheatgrass), *Descurainia sophia* (flixweed), *Lactuca serriola* (prickly lettuce), *Lepidium perfoliatum* (clasping pepperweed), Phragmites *australis* (common reed), *Polygonum ramosissimum* (bushy knotweed), *Polypogon monspeliensis* (annual rabbitsfoot grass), *Rumex crispus* (curly dock), *Sisymbrium altissimum* (tumbling mustard), *Tamarix ramosissima* (tamarisk), *Typha latifolia* (cattail), and *Xanthium strumarium* (cocklebur).

[2] Plant list partially adapted from Keate, Freshwater (EC < 7.5 dS) seasonal, semi-permanent, and permanent depressions.

[3] For slope wetlands, plant list is dependant on groundwater salinity. This list adapted from Keate, Freshwater seasonal and persistent slopes. In the event of more saline groundwater, the species list would be more similar to Keate, Moderately and hypersaline persistent slopes.

## Expected Plant Species for the Salt-affected Floodplain Habitat[4]

| Scientific name | Common name | Wetland indicator status | Sub habitat: | | | |
|---|---|---|---|---|---|---|
| | | | Salt meadow | Evaporative basins | | Brackish marsh |
| | | | | Type A | Type B | |
| *Chenopodium rubrum* | red goosefoot | OBL | X | | | |
| *Deschampsia caespitosa* | tufted hairgrass | FACW | X | | | |
| *Distichlis spicata* | saltgrass | FAC+* | X | X | X | X |
| *Eleocharis palustris* | common spikerush | OBL | X | | | |
| *Heliotropium curassavicum* | salt heliotrope | OBL | X | | | |
| *Hordeum jubatum* | foxtail barley | FAC* | X | | | |
| *Hordeum pusillum* | little barley | FAC | X | | | |
| *Muhlenbergia asperifolia* | scratchgrass | FACW+ | X | | | |
| *Puccinellia nuttalliana* | Nuttall's alkaligrass | OBL | X | | | |
| *Salicornia rubra* | pickleweed | OBL | | X | X | |
| *Schoenoplectus maritimus* | alkali bulrush | NI | | | | X |
| *Sporobolus airoides* | alkali sacaton | FAC | X | | | |

The following invasive/non-native/cosmopolitan species may be difficult to eradicate and are therefore expected to be found in the plant species composition: *Agrostis stolonifera* (creeping redtop bentgrass), *Atriplex micrantha* (orache), *Bassia hyssopifolia* (bassia), *Bromus japonicus* (Japanese brome), *Cressa truxillensis* (spreading alkaliweed), *Euthamia occidentalis* (western goldentop), *Iva axillaris* (povertyweed), *Lactuca serriola* (prickly lettuce), *Malvella leprosa* (alkali mallow), *Phragmites australis* (common reed), *Polygonum ramosissimum* (bushy knotweed), *Polypogon monspeliensis*, (annual rabbitsfoot grass), *Rumex crispus* (curly dock), *Tamarix ramosissima* (tamarisk), and *Xanthium strumarium* (cocklebur).

[4] Plant list partially adapted from Keate, Hypersaline (EC > 22.5 dS) seasonal or semi-permanent depressions.

## Expected Plant Species for the Riparian Habitat

| Scientific name | Common name | Wetland indicator status | Streambank | Green Zone |
|---|---|---|---|---|
| Deschampsia caespitosa | tufted hairgrass | FACW | | X |
| Distichlis spicata | saltgrass | FAC+* | | X |
| Eleocharis palustris | common spikerush | OBL | X | X |
| Elymus glaucus | Blue wildrye | FACU | | X |
| Festuca rubra | red fescue | FAC | | X |
| Juncus arcticus | arctic rush | FACW | X | X |
| Juncus torreyi | Torrey's rush | FACW+ | X | X |
| Muhlenbergia asperifolia | scratchgrass | FACW+ | | X |
| Populus fremontii | Fremont cottonwood | FACW* | X | X |
| Puccinellia nuttalliana | Nuttall's alkaligrass | OBL | | X |
| Ribes aureum | golden currant | FACW | | X |
| Salix amygdaloides | peachleaf willow | FACW | X | X |
| Salix exigua | narrow leaf willow | OBL | X | X |
| Schoenoplectus acutus | hardstem bulrush | OBL | X | |
| S. americanus | Olney's threesquare | OBL | X | |
| S. maritimus | alkali bulrush | NI | X | |
| S. tabernaemontani | hardstem bulrush | OBL | X | |
| Sporobolus airoides | alkali sacaton | FAC | | X |

The following invasive/non-native/cosmopolitan species may be difficult to eradicate and are therefore expected to be found in the plant species composition: *Agrostis stolonifera* (creeping redtop bentgrass), *Atriplex micrantha* (orache), *Bassia hyssopifolia* (bassia), *Bromus japonicus* (Japanese brome), *Cressa truxillensis* (spreading alkaliweed), *Euthamia occidentalis* (western goldentop), *Iva axillaris* (povertyweed), *Lactuca serriola* (prickly lettuce), *Malvella leprosa* (alkali dollarweed), Polygonum ramosissimum (bushy knotweed), *Phragmites australis* (common reed), *Polypogon monspeliensis*, (annual rabbitsfoot grass), *Rumex crispus* (curly dock), and *Xanthium strumarium* (cocklebur).

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